

# **Annual Industrial Capabilities**

## **Report to Congress for**

**2014**



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Office of the Under Secretary of Defense  
for Acquisition, Technology, and Logistics

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for Manufacturing and Industrial Base Policy

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## **1. Requirement**

This report is being provided to the Committee on Armed Services of the Senate and the Committee on Armed Services of the House of Representatives. This report simultaneously satisfies the requirements pursuant to Title 10, U.S.C., section 2504, which requires the Department of Defense (DoD) to submit an annual report summarizing DoD industrial capabilities-related guidance, assessments, and actions and Senate Report 112-26, which accompanied the National Defense Authorization Act (NDAA) for Fiscal Year 2012, and requires a report containing a prioritized list of investments to be funded in the future under the authorities of Title III of the Defense Production Act. This report summarizes DoD industrial capabilities-related guidance, assessments, and actions initiated during 2014 and as they existed at the close of that year. It is important to note that the status of some of the programs described herein has changed in the intervening time.

## **2. Defense Industry Outlook**

The defense industrial base (DIB) is a diverse and dynamic set of companies and DoD organic facilities that provide both products and services, directly and indirectly, to the DoD, and national security agencies to support national security objectives. It includes companies of all shapes and sizes from some of the world's largest public companies to small businesses. The Department relies on an industrial base that is now far more global, commercial, and financially-complex than ever before.

As the DIB continues to diversify, DoD contractors must constantly examine and realign their business activities while competing for capital in competitive markets. When DoD budgets are under pressure, as they have been in recent years, company planning and adjustment is complicated by the uncertainty of future defense contracts. The good news is that our larger defense companies remain profitable; they are carefully managing shareholder value through equity buybacks, debt reduction, reduced capital expenditures, and reductions in the labor force. Overall, our defense industry remains viable and highly competitive. Reduced costs, more transparency, and accountability in spending can lead to greater efficiency. However, as research and development (R&D) and production spending continues to be under significant pressure, major stresses to the industrial base are appearing in the form of design and production delays for selected military products and services, including next-generation weapons systems vital to our national security.

Budget uncertainty, in part, impacts companies' investment in their defense portfolios and sometimes deters new firms from working with DoD. In some key sectors, for example, the United States is in danger of losing essential domestic sources or being reduced to a single qualified source. These critical gaps and weaknesses must be addressed on an urgent basis before they become magnified, more costly, and less amenable to mitigation.

### **2.1 Trends in Defense Sectors**

Since the 1990s, the DIB has seen erosion in multiple sectors, including fixed-wing aircraft, missiles, electronics, ground vehicles, and materials, with associated decreases in design

engineering and manufacturing capability. The United States still produces the best systems in the world, but in many cases, we both require and produce fewer of them. Typically, our large defense firms are more diverse and able to manage these downturns in spending. However, if budget trends continue, their ability to do so will decline.

Budget impacts are more dramatic and challenging in the lower sub-tiers of the DIB as smaller firms, with limited access to capital, must adapt to these same downturns. The growing number of industry consolidations further complicates this challenge. Fewer companies can reduce competitiveness, weaken the pool of prospective suppliers, and maximize supplier leverage. Moreover, the loss of additional firms makes it more and more difficult to obtain required supplies and services, leading to delays in production and unanticipated costs and price increases. If dependence on foreign or overseas U.S. producers increases, the supply chain becomes even more vulnerable to disruption.

Prior to the recent downturn, the Department did experience major procurement increases. However, they were heavily weighted toward supporting the Global War on Terrorism and on sustaining Overseas Contingency Operations (OCOs). In fact, the non-Science & Technology R&D accounts (specifically 6.4, 6.5, and 6.7), which are used to transition basic science and technology to warfighter application, dropped by 30 percent and procurement in this same area dropped by 44 percent<sup>1</sup> from 2008 through 2014.

Companies constantly adjust to market conditions – and when allowed to operate in this manner, they operate efficiently. However, free markets can also allow for industry consolidations that can unduly restrict competition and cause market distortions that can weaken the health of the industrial base. The Department must intervene in the marketplace only when necessary to maintain access to critical capabilities that might otherwise disappear. On occasion, this may require DoD to sustain supplier capacity to ensure continuity in design and development even if no new procurements in that sector are anticipated in the short term.

## **2.2 Technological Superiority**

As Mr. Frank Kendall, Under Secretary of Defense (Acquisition, Technology and Logistics) (USD(AT&L)), has noted on many occasions, R&D drives modernization. It still takes lead-time to get a new capability designed and tested, and then produced and acquired. Budget uncertainty can retard and disrupt this multi-phase process. Delays and under-funding can weaken industry suppliers that are dependent on steady DoD procurements to sustain their manufacturing operations and production levels on a scale needed to ensure both efficiency and profitability.

Accordingly, DoD is concerned about protecting the adequacy of our R&D investments in capabilities and systems that will allow DoD to dominate on future battlefields and keep engineering design teams who develop advanced defense systems. While all industrial sectors are challenged by rapid changes in DoD R&D funding, risk for defense-unique industrial sectors at the sub-tier supplier level is especially pronounced. Such suppliers may not have the diversity

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<sup>1</sup> both in constant dollars

of programs or products from other markets to support their design and production skills. One approach to ensuring continued innovation is for the Department to consider more effective means to incentivize industry to use internal R&D funds to invest in next-generation capabilities. Another is to increase the use of prototyping to reduce design risks and sustain system integration and design engineering skills.

The Department is deeply concerned about the loss of technical expertise and design teams that are sustained through new program development. Over the past decade, many industrial sectors have had no or few new-start opportunities in defense-specific areas that are currently undergoing a decline in procurement. Key sectors, which should be closely monitored, include next-generation tactical aircraft design and integration skills, ground combat vehicle manufacturing and production capability, trusted micro-electronics, and sub-tier suppliers in space and tactical and strategic missile systems. The combination of loss of design and production capability could result in costly delays, unanticipated new expenses and a reduction in military readiness across a wide range of current and future programs.

## **2.3 Data-Driven Assessments**

Cycles in budgets are not new to DoD. In order to better understand and track how procurement patterns affect the health of the industrial base, the DoD published a directive with a handbook in 1996 formalizing the assessment of defense industrial capabilities on a case-by-case basis (DoD Directive 5000.60H, 1996). Once an area of concern is identified, the handbook provides a framework to determine the need for government action to preserve industrial capabilities vital to national security. The framework is useful, but as written in 1996, was reactive and program-centric. While primes manage their individual supply chains effectively, the cumulative effect of multiple program procurement decisions can have unintended consequences on vital capabilities. Accordingly, DoD requires more proactive insight into the possible consequences of acquisition decisions in order to develop mitigation strategies and tools to address industrial base vulnerabilities before they reach the critical stage.

Building on the existing framework, the Office of the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy (MIBP) developed a methodology that could be used proactively across Services and industrial sectors that is rigorous, repeatable, and transparent. In late 2012 and through 2013, MIBP built on the existing 1996 framework to develop a methodology which became known as the Fragility and Criticality (FaC) assessment process. Chapters 4 and 5 of the revised DoD Instruction 5000.60 guidebook provide the assessment framework.<sup>2</sup> Throughout 2014, MIBP continued the work it began in 2013 to refine a more technically-rigorous methodology for identifying and mitigating weaknesses in the DIB.

## **2.4 Globalization**

Industry, in general, is becoming more integrated with global commercial markets. Even without the budget pressures, the simple fact is that the U.S. no longer has the luxury of

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<sup>2</sup> The revised DoD instruction 5000.60 (Dated July 18, 2014) and corresponding guidebook are available at <http://www.acq.osd.mil/mibp/policies.html> (Accessed February 1, 2016).

assuming that we are, or will be, the leader in new technology breakthroughs. Indeed, international collaboration and cooperation have reduced the time from technology breakthrough to product development. This single change requires that our acquisition process be able to take advantage of emerging capabilities regardless of where they originate.

Effective global supply chain integration and management are even more critical to DoD program success than in previous years. Globalization brings many benefits to both defense firms and the Department, such as leveraging the R&D efforts of commercial industry that would be impossible to replicate on a defense-unique basis. However, it also brings increased cross-border flows of information and technology, reducing our technological advantage. As a consequence, in technology and capability areas that are globally competitive, our goal is to obtain the best product to support the Warfighter at the best price from the international marketplace. However, for those enabling technologies that are critical to maintaining superiority over our adversaries, we seek to invest in domestic or allied partner firms.

## **2.5 Looking to the Future: DoD and the DIB**

Government and industry stakeholders are keenly aware of the significant ongoing pressures on the defense industrial base. Together we face the prospect of more sequestration limits which could severely impact investment accounts and weaken our defense posture, thwarting our ability to support the design and development of already scheduled systems. The good news is that defense markets are cyclical and there will be an upturn eventually – but we must be ready for it. Firms that succeed in the future will need to make strategic investments in new technology now. In recent years, companies in the DIB have shown a remarkable ability to continue to generate significant profits – with a shareholder-friendly capital deployment strategy, but their gains have frequently accompanied declines in company-sponsored investments in R&D.

Therefore it is imperative that DoD and industry strengthen their strategic collaboration to help position the industrial base for success in the coming years.

## **3. DoD Industrial Base Initiatives**

MIBP continues to develop innovative approaches to analyzing the health of the defense industrial base to satisfy its mission and responsibilities as authorized in law. MIBP seeks to protect capabilities that are most difficult to reconstitute through the use of the Industrial Base Sustainment Fund, ManTech, and Title III programs. When necessary, MIBP raises industrial base concerns through the Defense budgetary process. MIBP works closely with stakeholders across the Department and government to introduce and expand on current initiatives such as the Administration's focus on Advanced Manufacturing through the National Network for Manufacturing Innovation, and the continuation of Better Buying Power efforts.

### **3.1 MIBP Authorities**

Section 896 of the Ike Skelton NDAA for Fiscal Year 2011 (P.L. 111-383) established the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy

(DASD(MIBP)). MIBP supports the Office of the Secretary of Defense and the Service Acquisition Executives by: (1) providing detailed analyses and in-depth understanding of the increasingly global, commercial, and financially-complex industrial supply chain essential to our national defense; and (2) recommending or taking appropriate actions to maintain the health, integrity, and technical superiority of that supply chain. In addition to MIBP's core mission to broadly assess and address the health and resiliency of the DIB (Title 10, U.S.C., sections 2501, 2503, 2505, and 2506), it oversees important program and policy functions, including:

- The title 50, U.S.C., Defense Production Act (DPA) of 1950, Title I, Defense Priorities and Allocations System;
- The title 50, U.S.C., DPA Title III program, Expanding Production Capability and Supply;
- The title 10, U.S.C., section 2521 Manufacturing Technology (ManTech) program;
- The title 50, U.S.C., DPA Title VII, Section 721, Committee on Foreign Investment in the United States (CFIUS);
- The title 50, U.S.C., DPA Title VII, Section 722 of the DPA, Defense Production Act Committee (DPAC); and
- The title 10, U.S.C., section 2372, Independent Research and Development.

This extensive and diverse portfolio enables MIBP's holistic focus on defense manufacturing, production, and industrial base issues.

### **3.2 Presidential Commitment to Advanced Manufacturing Initiatives**

Throughout 2014, both the Administration and the Department have given the highest priority to advancing manufacturing capabilities within DoD and throughout the nation. One example of this emphasis is MIBP's leadership in the establishment of three public-private partnerships for advanced manufacturing on behalf of the Department. MIBP is furthermore in the midst of establishing three additional institutes in the coming year. Each of these institutes will be part of the recently-authorized National Network for Manufacturing Innovation (NNMI), focused on successful scale-up of emerging, world-leading advanced manufacturing capabilities, enabling U.S. industry to maintain its edge in a hypercompetitive global environment and to meet vital economic and national security needs. Technological innovation and leadership in manufacturing are essential to maintaining technological advantage and global dominance for our military over our adversaries. To support these goals, Manufacturing Innovation Institutes (MIIs), will serve as regional hubs to accelerate technological innovation into commercial applications and concurrently develop the educational competencies and production processes via shared public-private sectors. This same office successfully launched the pilot institute, American Makes, which officially opened on September 27, 2012, and is currently funded at over \$110M. America Makes will serve as a training and collaboration center to bridge the gap between basic research and technology adoption for additive manufacturing. More commonly known as "3D Printing," additive manufacturing is an enabling manufacturing technology for our military platforms. Key manufacturing initiatives undertaken in 2014 include:

- In February of 2014, the Department launched two additional Institutes: Lightweight Innovations for Tomorrow (formally known as the Lightweight and Modern Metals Manufacturing Innovation (LM3I) Institute), located in Detroit, MI, with a total \$148M investment over five years, and Digital Manufacturing and Design Innovation (DMDI) Institute, located in Chicago, IL, with a total investment of \$176M over five years.
- MIBP is working to establish three additional Institutes in 2015: Integrated Photonics Manufacturing, Flexible Hybrid Electronics Manufacturing, and Revolutionary Fibers and Textiles Manufacturing.

### **3.3 Expanded Efforts to Incorporate Industrial Base Impacts in the Department's Budget Deliberations**

The Department has continued efforts initiated in the fiscal year (FY) 2013 budget cycle to assess the effects of program adjustments on the industrial base. In 2012, the USD(AT&L) created a process to work with the Military Departments (MILDEPs) to identify critical and fragile industrial base niches involved in the supply chains for major defense acquisition programs. MIBP spearheaded these FaC assessments in order to analyze the portfolio of critical and fragile capabilities across the defense enterprise and inform DoD budget discussions. The Department may use information from these analyses, for example, to make acquisition decisions to ensure a smooth workflow, especially by considering the impact of spending across different programs that have a common sub-tier supplier that is considered at risk. This effort is described in more detail in section 4.0, "Fragility and Criticality Assessment."

FY 2014 also witnessed the creation of the Industrial Base Analysis and Sustainment (IBAS) Program as a new funding vehicle to address critical capability shortfalls in the base. Capabilities that are at-risk of being lost and cross Service/DoD-Agency boundaries are specifically targeted. The goal is not to sustain all capabilities indefinitely but to avoid reconstitution costs when capabilities are likely to be needed in the foreseeable future. IBAS makes investments only when sustainment is more cost-effective than reconstitution and results in overall cost savings to the Department.

IBAS-funded projects addressing critical issues and supply chain vulnerabilities are identified by three basic methods: 1) existing knowledge, 2) new FaC industrial base assessments, and 3) nominations from the Services and DoD agencies. The positioning of IBAS among the spectrum of risk reduction programs is found in its name: "sustainment." Preservation includes design teams as well as capabilities to produce existing products. While innovation is not the primary objective, it is certainly compatible, and is frequently an indispensable partner to preserving both design teams and production capabilities.



The IBAS program preserves fundamental industrial capabilities across three focus areas and since the program's inception, it has sponsored 10 efforts. These include:

- Lifelines and safe harbors to preserve unique capabilities:
  - Counter Bomber
  - Cycletron
  - Electromechanical actuator planetary roller screw
  - Thermal batteries
- Design teams to preserve critical skills:
  - Focal plane arrays
  - Advanced solid rocket propulsion
  - Fuzes
- Industrial base supply, expansion and competition to expand the Department's access to reliable sources:
  - Butanetriol
  - Low energy expanding foil initiator
  - Radiation hardened bi-polar transistors

### **3.4 Continuation of the Better Buying Power Initiative**

Better Buying Power (BBP) is based on the principle of continuous improvement to the performance of the defense acquisition enterprise. The Department introduced BBP in 2010 with a focus on helping acquisition professionals think critically and make better decisions as they confront the myriad, complex situations encountered in defense acquisition. In 2013, adjustments to BBP 1.0 were made based on experience during its implementation and feedback from industry and government. BBP 2.0 focused on professionalism and providing better tools to help DoD acquisition professionals make sound decisions.

In September 2014, BBP 3.0 was introduced with the overarching theme of "Achieving Dominant Capabilities through Technical Excellence and Innovation." BBP 3.0 promotes earlier efforts and adds initiatives that encourage innovation and promote technical excellence to help ensure that the United States military has the dominant capabilities to meet future national security requirements. Through the fall of 2014, the Department developed a series of white papers intended to form the basis of implementation guidance, which will be released in 2015.

BBP 3.0 will focus attention on the overriding concern that our nation's technological superiority is at risk. New emphasis areas include:

1. Long-range research and development
2. Cybersecurity
3. Commercial technology
4. Prototyping and experimentation
5. Modular open system architecture
6. Global technology
7. Organic engineering capabilities
8. Science, technology, engineering, and mathematics (STEM) education

As with BBP 1.0 and 2.0, there is an element of cultural change in BBP 3.0. BBP 1.0 and 2.0 focused on cost consciousness and professionalism, and BBP 3.0 upholds earlier initiatives including items such as affordability constraints, should-cost management, use of data to inform policy, strong incentives to industry, and the use of competition. As such, BBP 3.0 will continue to focus on controlling costs, critical thinking and sound professional management, and will include new initiatives aimed at reinvigorating the Department's partnership with industry to develop, produce, and sustain the systems that offer American warfighters a technological edge.

### **3.5 Increased Cooperation on Materials Industrial Base Assessments**

Section 901 of the National Defense Authorization Act for FY 2013 (P.L. 112-239) addresses a specific facet of the industrial base: the availability of materials critical to national security. MIBP shares with the office of the Defense Logistics Agency Strategic Materials (DLA SM) the responsibility for assessing the material needs of the defense industrial base, assessing the robustness of the associated material supply chains, and, as appropriate, developing, implementing, and monitoring policies to ensure the availability of required materials. The legislation also reconfigures the Strategic Materials Protection Board (SMPB) such that it will now be chaired by the DASD(MIBP), while the Administrator of DLA SM serves as vice-chair. In the past, the SMPB was chaired by the USD(AT&L).

MIBP recognizes the goal of Congress and the synergies to be gained from a strategy that emphasizes a more centralized approach by the Department to issues concerning the supply of materials critical to the DIB. Therefore, the DASD(MIBP) and the Administrator of DLA SM signed a letter of intent in March 2014 that outlines areas of cooperation for the offices to ensure the availability of raw materials for the DIB as well as on the SMPB.

## **4. Fragility and Criticality Assessment**

Throughout 2014, MIBP continued the work it began in 2013 to refine the Sector by Sector, Tier by Tier (S2T2) process established in 2010 with a more technically rigorous and timely methodology for identifying and mitigating weaknesses in the DIB based on the broad framework established earlier by the Department. This refined methodology is now called a Fragility and Criticality (FaC) assessment. FaC is a more technically-rigorous methodology for identifying and mitigating weaknesses in the DIB based on the broad framework established by DoD in 1996. The new methodology involved subject matter experts in a sustained process of identifying and assessing the most vulnerable sectors, with breakdowns by sector tier and sub-tier. The methodology is intended to serve as a model for other agencies (see Table 4.1). Over the next year or two, MIBP plans to develop predictive tools to enhance its efforts to refine this methodology.

“Fragility” and “criticality” are roughly analogous to the traditional risk factors of probability and consequence. Fragility characteristics are those that make a specific product or service likely to be disrupted. Criticality characteristics are those that make a product or service difficult to replace.

MIBP’s revised assessment model is based on four fragility factors, and six criticality factors – a total of ten factors. This is a substantial reduction from the fourteen factors used in MIBP’s FY 2013 FaC assessments. After reviewing the results of last year’s assessments, and with additional technical input, MIBP replaced or consolidated several factors to create a more simplified and efficient model.

Table 4.1 lists the ten factors used in the current assessment model. The four fragility factors are the total number of firms engaged in manufacturing a product or service, their current DoD sales level and broad financial outlook, and their degree of foreign dependency. The six criticality factors are the skilled labor, design, and facility/equipment requirements needed to produce a military product or service, its “defense-uniqueness,” the availability of alternative sources, and the time and cost required to replace it.

Table 4.1 <i>FaC Assessment Metrics</i>	
<b>“FRAGILITY”</b>	
• Financial Outlook (current provider)	• Firms in Sector (existing market)
• DoD Sales (current provider)	• Foreign Dependency (existing market)
<b>“CRITICALITY”</b>	
• Facility/Equipment Requirements	• Defense-Uniqueness
• Skilled Labor Requirements	• Reconstitution Time
• Defense Design Requirements	• Availability of Alternatives

MIBP subject matters experts, mostly drawn from the four military services, performed FaC assessments on all major DoD procurement categories. Several key sectors were highlighted as especially vulnerable or in need of ongoing MIBP monitoring based on the FaC scoring system and on additional input from the military services.

In 2014, the Department completed seven new FaC assessments that identified important risks in the industrial base and provided actionable mitigation strategies to DoD leadership. The assessments confirmed with supporting data that space and missiles continue to be two sectors under particular stress. Design teams for fixed-wing fighter aircraft was added as an industrial area of concern.

From the data explorations and statistical analysis, MIBP confirmed that FaC assessments are reliable measures of DIB robustness and vulnerability based on factors such as a supplier’s availability, defense-uniqueness, foreign dependence, and susceptibility to supply chain

disruptions. The 2013 pilots also suggested ways to refine these constructs and to enhance the FaC assessment process as a whole.

In late 2013, a Deputy Management Action Group (DMAG) incorporated results from the 11 FaC assessments into planning for the FY2014 budget. After careful review, the DMAG recommended investing \$40M over the Future Years Development Plan (FYDP) to address weaknesses in the missile industrial base for fuzes and thermal batteries. The Department utilized the IBAS program to execute these programs.

In 2014, an industrial base DMAG addressed industrial capability risks identified through a space sector industrial base FaC assessment and a number of Department assessments centered on unique critical design capabilities. The DMAG recommended addressing vulnerabilities in at risk space subtier suppliers and allocated \$28M for this effort. The DMAG also addressed critical fixed-wing design capabilities.

## **5. Industrial Sector Assessments**

The following sub-sections review the results of the main MIBP assessments conducted during FY2014. Subsequent sections of this report review the results of additional assessments, including those conducted by MIBP in conjunction with other agencies.

### **5.1 Aircraft Sector Industrial Summary**

#### Industry overview.

The aircraft sector is highly defense-unique. Three main types of military aircraft are produced and procured by DoD. Although Unmanned Aircraft Systems (UAS) are considered either fixed or rotary wing aircraft; for assessment purposes, MIBP treats UAS as a separate sub-sector:

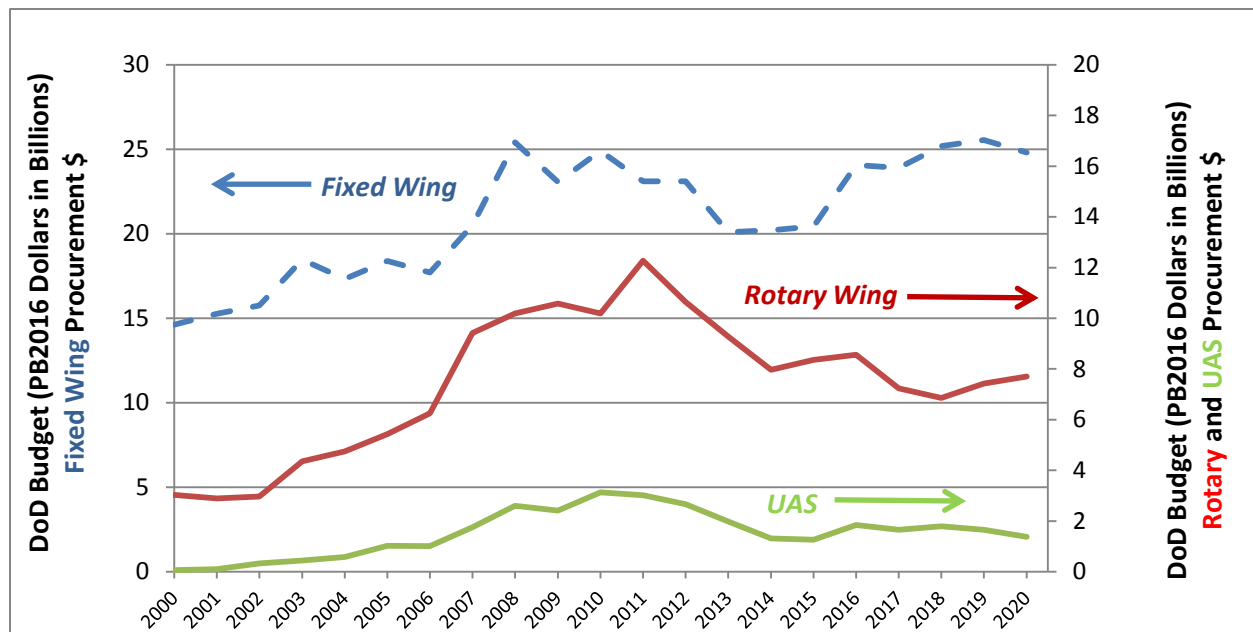
- *Fixed Wing* includes fighters, bombers, cargo, transportation, and any manned aircraft that uses a set of stationary wings to generate lift and fly. Large airframes and subsystems rely heavily on commercial technologies, processes, and products, and will be sustained by ongoing and planned military and commercial aerospace programs. However, defense-unique design and manufacturing skills are needed to meet the requirements of military weapon systems, produce next-generation aircraft, and maintain technological advantage.
- *Rotary Wing* includes the helicopters used for a variety of military missions that fall into three main areas: combat, combat support, and services. Unlike commercial helicopters, DoD helicopters operate in harsh battlefield environments, which require robust and advanced capabilities and systems such as fire control, armor, weaponry, night vision, advanced avionics, stealth, speed, and power. As a result, unique design and engineering capabilities are needed to design, produce, and test DoD helicopter systems. These capabilities are not required for the commercial market.
- *Unmanned Aircraft Systems* includes the necessary components, equipment, network, and personnel to control an unmanned aircraft; in some cases, the UAS also includes a launch

and recovery element. UAS's typically fall into one of six functional categories (although multi-role airframe platforms are becoming more prevalent): target and decoy, reconnaissance, combat, logistics, research and development, and civil/commercial. The growing demand for increasingly sophisticated and versatile unmanned systems reflects the Warfighter's need for intelligence, surveillance and reconnaissance support that can reduce the risk to combat forces and associated deployment costs.

### Budget considerations.

Procurements for fixed wing aircraft dominate the aircraft sector. As indicated in Figure 5.1.1 below, funding for fixed-wing military aircraft peaked in 2008 at \$25 Billion and “bottomed out” at \$20 Billion in 2014. Under current budget planning, funding is projected to increase to \$24 Billion by 2016 with a slow but steady increase until 2020. Funding for UAS exhibits a similar peak-and-decline pattern. Funding reached \$3 Billion in 2010, but declined sharply to \$1.3 Billion by 2014. The procurement investments in the UAS sub-sector will stay stable from 2016 onward. Funding for rotary wing aircraft peaked in 2011 at \$12.3 Billion and declined to roughly \$8 Billion in 2014. While funding for rotary wing is scheduled to increase through 2016, a sharp decline is expected by 2018. However, rotary wing projections for 2019 and 2020 indicate an increase in procurement funds.

Figure 5.1.1: Aircraft Procurement Funding Profile



Source: Defense Research Data Warehouse

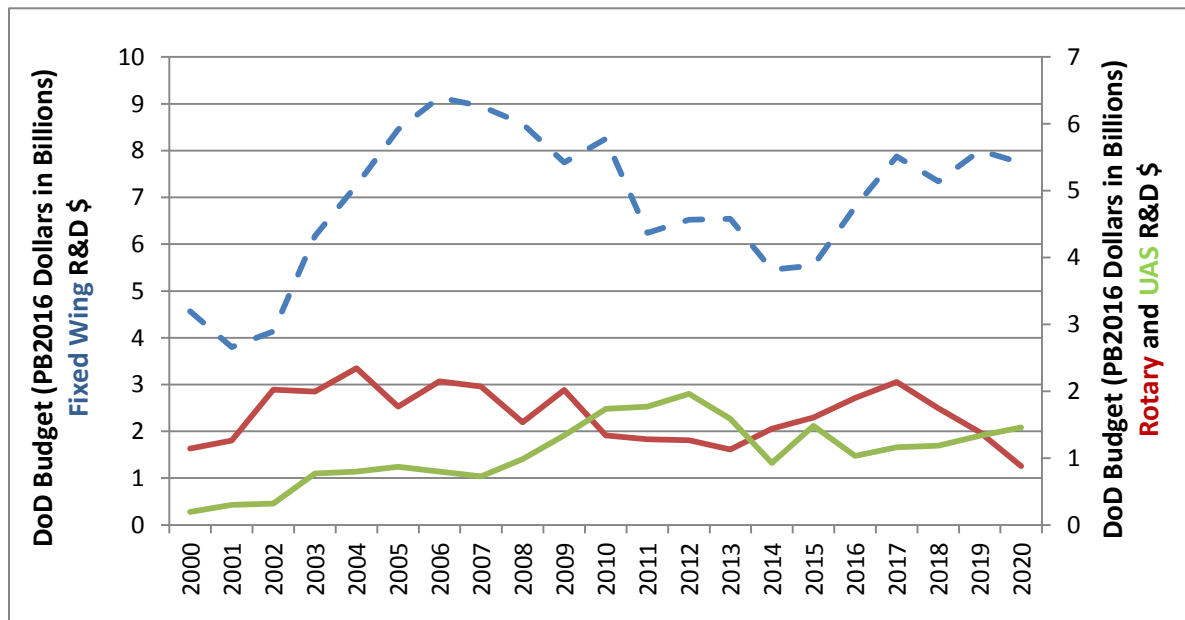
Near-term DoD aircraft development programs forecasted for the FY 2015 DoD budget are listed in Table 5.1.2. The Air Force is developing next-generation fighters and bombers as a top priority. The Navy is introducing a new UAS system, while the Army is developing a new future vertical lift (FVL) rotary capability.

Table 5.1.2: Future Aircraft programs (FY 2015)

<i>Program</i>	<i>Type</i>	<i>Lead Service</i>	<i>Award Year</i>
Long Range Strike-Bomber (LRS-B)	Fixed Wing	Air Force	2015
Trainer (T-X)	Fixed Wing	Air Force	2016
Carrier Based Aerial Refueling System (CBARS), formerly known as the Unmanned Carrier Launched Airborne Surveillance and Strike (UCLASS)	UAS	Navy	2018
FVL	Rotary Wing	Army	2021

With developments at this level, and with an overall 16% decline in funding for this sector, the main challenge will be to support expanded design capabilities across the board. Funding patterns for research, development, test, and evaluation (RDT&E) in the aircraft sector are depicted in Figure 5.1.3.

Figure 5.1.3: Aircraft RDT&E Funding Profile



Source: Defense Research Data Warehouse

The UAS sub-sector experienced a decline in funding during 2014. Funding for fixed wing was at the lowest level since 2003. The rotary wing funding slightly increased in 2014. R&D funding for fixed and rotary wing sub-sectors is expected to increase from 2015 to 2017. After 2017, a sharp decline in rotary wing funding is expected. New funding that allows for expanded engineering and manufacturing development (EMD) activities may not sustain the prime contractor design teams needed to design the next generation of fighters and helicopters in the 2020s.

## Industry Suppliers

Seven companies provide the majority of aircraft platforms and possess the full range of capabilities to bring a new weapon system from the research, design, and development phases into full production. The seven firms are among the largest U.S. defense contractors, including Boeing, Lockheed Martin, Northrop Grumman, Sikorsky, Bell Helicopter, Airbus Helicopter, and General Atomics. The systems produced by each company are listed in Table 5.1.4.

Table 5.1.4: Prime Contractors for Major Aircraft Acquisition Programs (includes previous major programs that are not currently in production)

Aircraft Sector Prime Contractor	Fixed Wing	Rotary Wing	UAS
Boeing	A-10, B-52, B-1, F-15, EA-18G Growler, F/A 18-A-F Super Hornet, KC-46A	CH-47F Chinook, V-22 Osprey Fuselage, AH-64D Apache New & Remanufacture	Scan Eagle  Blackjack
Lockheed Martin	F-35, F-22, F-16, C-130J, P-8A Poseidon	MH-60 assembly	Sentinel UAS
Northrop Grumman	EA-6 Prowler, T-38, B-2	N/A	Global Hawk, Triton, BAMS, MQ-8 Fire Scout
Sikorsky	N/A	UH-60 Blackhawk, MH-60S, VH-92A Presidential, CH-53K, MH-60R	N/A
Bell Helicopter	N/A	AH-1 W, UH-1 Huey, V-22 Osprey	N/A
Airbus Helicopter	N/A	Light Utility Helicopter	N/A
General Atomics	N/A	N/A	Gray Eagle, Predator B, Predator C, and Predator XP

## Risk Assessment

The Department is focusing on defense-unique aerospace capabilities that could be at risk and that are not sustained by the commercial market. Our main concern is the industry's ability to sustain the skills and capabilities needed for future aircraft design and manufacture. DoD completed assessments for all three areas of the aircraft sector.

- *Fixed Wing:* The Military Aviation Industrial Base Review assessed industry’s ability to support DoD at the prime contractor level. The data indicated that new procurements combined with modernization programs will help to sustain defense-unique critical capabilities. However, these programs will not exercise all the skills needed for designing, manufacturing, testing, evaluating, and certifying new fighter platforms. In addition, the pool of engineers with the requisite skill sets for aircraft development and manufacturing is retiring without opportunities to train new engineers in a “hands-on” environment. The report recommended the use of prototypes to sustain the design and manufacturing capabilities needed to support new combat aircraft programs beginning in the 2020s.
- *Rotary Wing:* The IB in this sub-sector has been focused increasingly on the remanufacture and refurbishment of legacy platforms. The Military Rotary Wing Design and Engineering Capabilities Assessment indicated that current engineering changes and EMD platforms are sufficient to sustain engineering and design teams until 2020. However, there is a concern that the lack of new development efforts, beyond 2020, will cause the base to transition away from military-unique development. Sustaining engineering and design teams needs to be prioritized.
- *UAS:* The biggest risks to the UAS fleet is the lack of Science and Technology and Original Equipment Manufacturer Independent Research and Development investment to prepare for the increasing demand for UAS to meet current/future requirements. DoD UAS operations need propulsion improvements (reliability/performance) for Group IV and below aircraft, expeditionary/vertical takeoff and landing capability, and increased cyber/encryption capability to protect against system vulnerabilities. Nevertheless, rising demand for UAS will expand opportunities for industry on many fronts. Open architecture and common airframes will increase economies of scale for large producers while broadening the base of small subsystems manufacturers. Increasingly sophisticated UAS capabilities will require greater communication bandwidth, opening opportunities for military as well as commercial satellite systems. Additionally, to fill gaps in organic maintenance, contractors may be needed to service greater numbers of more advanced UAS. To continue advancing UAS capabilities, government and industry need to work together to address the relevant policy, legislation, and doctrinal changes required.

### Long-Term Challenges

- There has been a steady decline in the number of defense development programs for fixed-wing and rotary-wing aircraft. Modernization programs will help sustain important capabilities such as avionics, electronic warfare, limited structural changes, software development, and weapons integration. However, they will not provide opportunities for major design, development, and integration work. With the approaching end of development programs and an absence of new requirements in the next five to seven years, critical design capabilities are facing shortages.
- Design shortfalls are also projected because much of the defense aerospace workforce is close to retirement, and the pool of young engineers available to replace them is



dwindling. Historically, engineering know-how and critical classified knowledge was passed from one generation of engineers to the next through collaborative hands-on, real-time execution of relevant work. However, over the past 25 years or more, opportunities for this type of knowledge transfer have been very limited. Therefore, future technical challenges are likely to be tackled by engineers with significantly less experience than the generation before. The consequences may include longer and more expensive development and initial production costs.

### Recent Mitigation Efforts

- DoD is beginning to fund aircraft prototypes as part of the Aerospace Innovation Initiative begun in the fall of 2014. For example, a project to build aircraft prototypes will allow the Department to cover the design gap between the F-35 program and the next-generation of fighters. Prototyping design and manufacturing will also provide the hands-on experience that new engineers in the aerospace field need.
- DoD is also working to provide additional information on platform requirements for next-generation and clarifications to the FVL vertical lift programs through the FVL effort program and Joint Multi-Role (JMR) technology demonstrators (TD). FVL is developing five capability sets based on DoD vertical lift missions and requirements with common mission system architectures to support avionics, sensors and engines. These vertical lift assets are projected to replace the Blackhawks across the services, Apache, Chinook, Kiowa and Marine Corps AH-1/H-1 platforms. JMR TD (Sikorsky-Boeing - SB-1 Defiant and Bell-Lockheed Martin - V 280 Valor) are intended to transition capabilities and will ultimately inform FVL program efforts. Twelve rotorcraft platforms are currently in production and three rotorcraft platforms are in Engineering, Manufacturing and Development. All of these platforms will be out of production by 2026.

## **5.2 Electronics Sector Industrial Summary**

### Industry overview

The global electronics industry produces for a wide variety of end user markets including: consumer electronics, computers, automotive, industrial equipment, medical equipment, telecommunications, and aerospace/defense. Although electronic systems and components are ubiquitous throughout all DoD weapons systems, the DoD represents only a very small fraction of a market which is today is dominated by consumer devices. That means DoD must keep abreast of market trends to ensure ready access to the most critical components needed by defense-unique suppliers.

The electronics supply chain consists of main supplier types that reflect the diversification and globalization of electronics manufacturing. They include:

- Original Equipment Manufacturers (OEMs)
- Contract Manufacturers – Electronic Manufacturing Services (EMSs) and Original Design Manufacturers (ODMs)

- Printed Circuit Board (PCB) manufacturers<sup>3</sup>
- Semiconductor (a.k.a. Chip) manufacturers

U.S. OEMs began moving assembly of their products to countries with cheaper labor rates – primarily to Asia – in the 1980s. In the 1990s, this trend continued with the outsourcing of the manufacturing of the product to international EMS contract manufacturers. EMS contract manufacturers make and/or assemble products on contract, typically for a number of different OEMs who then brand the products and sell them to customers. By the 2000s, some contract manufacturers had advanced in skill to also do the design work. These contract manufacturers are called Original Design Manufacturers. Today, many U.S. companies will buy their product from ODMs and will then brand and sell it as their own.

A similar dynamic has taken place with semiconductor and PCB manufacturers. Semiconductor manufacturers have segregated into Integrated Device Manufacturers (IDM) which design, manufacture, and sell semiconductors; fabless companies which only do design; and foundries which only do manufacturing. PCB manufacturing is dominated by large multinational contract manufacturers.

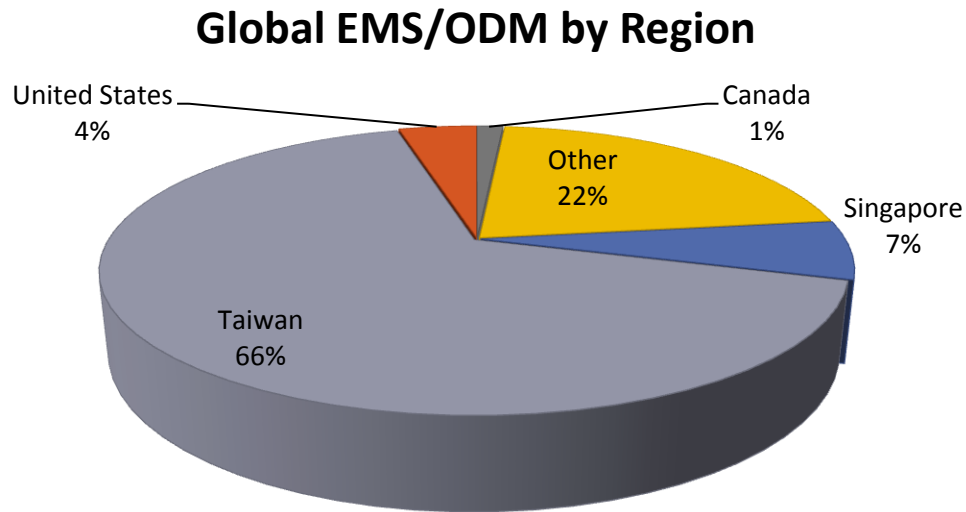
### **Industry Assessments.**

*EMS and ODM:* Combined, 2014 revenue for EMS and ODM companies totaled \$408B, 73% of which went to Asian companies (see Figure 5.2.1). By revenue, Taiwanese companies dominate with seven of the top ten EMS/ODM companies for a combined market share of 66%. In particular, Hon Hai Precision Industries alone has a 34% market share. The sole U.S. company in the top 10 is Jabil Circuit Inc. which is a multinational corporation headquartered in the U.S. Other smaller U.S. companies in the EMS/ODM space include Sanmina-SCI Corp, Benchmark, and Plexus Corp.

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<sup>3</sup> Printed circuit boards (PCBs or PrCBs) are the foundation for all electronic equipment. PCBs mechanically support and provide electrical connections between electronic components in an electronic device.

Figure 5.2.1 Global EMS/ODM revenue by region (2014)



Source: Bloomberg, International Data Corporation

*PCB Manufacturers:* As in the overall electronics market, the global PCB market has experienced explosive growth while the North American industrial base continues to decline and consolidate due to the movement of the industry to Asia. This has resulted in reductions of both the number of domestic manufacturers and their ability to provide state-of-the-art PCBs. As a result, DoD is becoming more dependent on foreign-sourced PCB products. The number of domestic PCB manufacturers has decreased dramatically from more than 2,000 in the 1980s, to 680 in the year 2000, to 280 in 2014<sup>4</sup>. This consolidation has continued this year with the merger of TTM Technologies, Inc. the largest domestic PCB manufacturer with Viasystems Group, Inc., the second largest domestic PCB manufacturer.

While the U.S. PCB industrial base has declined, the world market for PCBs has grown dramatically. From a \$30B market in the year 2000, the market doubled to \$60B in 2013<sup>5</sup>. During the same period, U.S. production declined, decreasing by 70% from \$10 Billion to \$3 Billion.<sup>6</sup> In 2014, the majority of the PCB industrial base was in Asia, which accounts for almost 90% of worldwide production with only 5% in the U.S. (see Figure 5.2.3). With these trends, the U.S. military has become increasingly more reliant on foreign suppliers to meet critical military PCB requirements. And, consequently, U.S. suppliers have also become increasingly more reliant on the U.S. military to survive. In 2014, the aerospace/defense segment represented 27% of the domestic PCB market (see Figure 5.2.2).

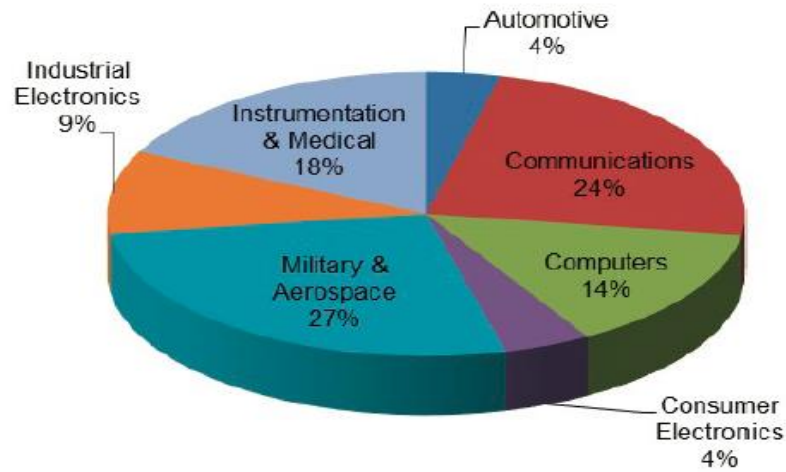
<sup>4</sup> H. Miller, "FabFile Online," [Online]. Available: <http://www.fabfileonline.com>.

<sup>5</sup> World Electronic Circuits Council (WECC), "WECC Global PCB Production Report for 2014", WECC, October 2015.

<sup>6</sup> *ibid*

Figure 5.2.2 World Printed Circuit Production by Geographical Area

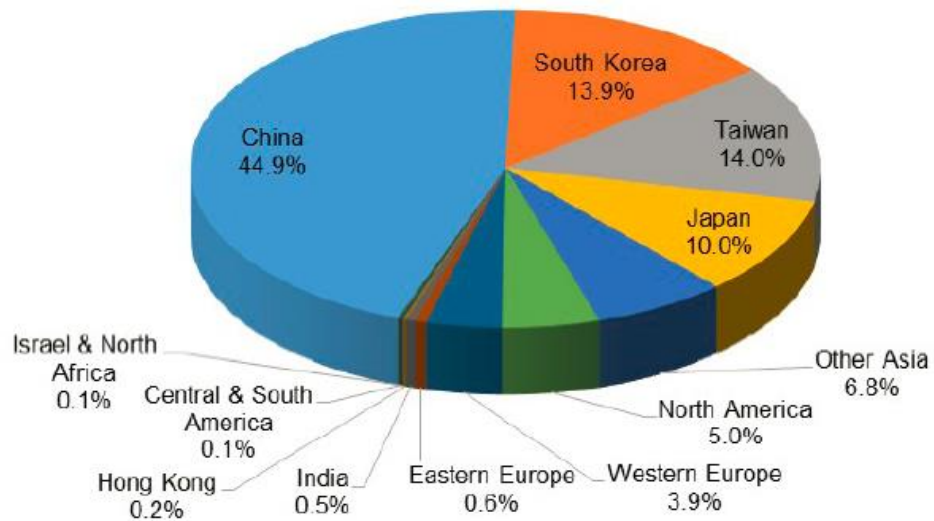
**2014 Vertical Markets for PCBs  
in North America**



Source: Bloomberg, International Data Corporation

Figure 5.2.3 2014 North American PCB Production by End Market

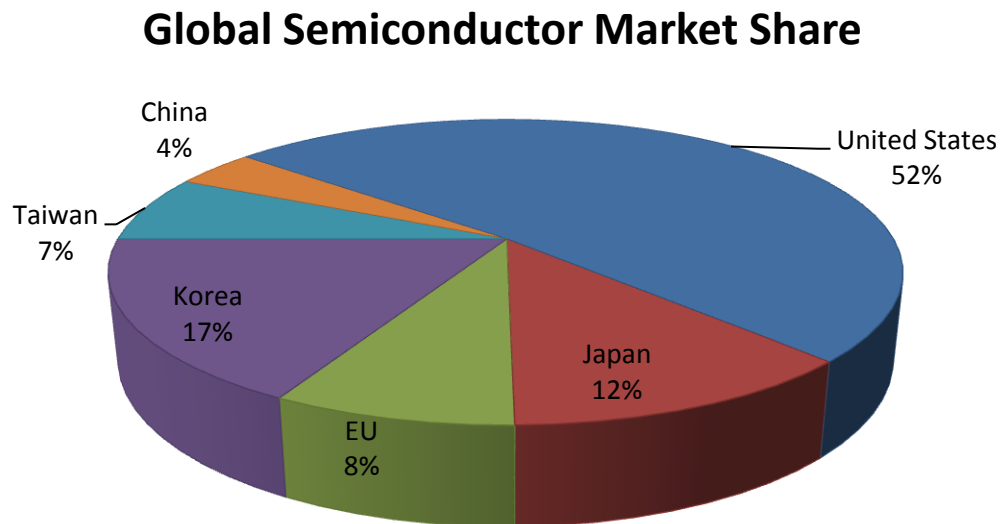
**PCB Production by Major Producing Countries and  
Regions in 2014 Reported by WECC-Member Associations**



Source: Bloomberg, International Data Corporation

*Semiconductor manufacturers*<sup>7</sup>: Despite the loss of much of the electronics industry to Asia, the United States still maintains its leadership in semiconductors. In 2014, sales of U.S. semiconductor companies represented 52% of the global market. Asia represented 40% of the market and Europe 8% (see Figure 5.2.4). Worldwide semiconductor sales have experienced steady growth over the past two decades, rising over 200% from \$101.9B in 1994 to \$335.8B in 2014. During the same period, U.S. semiconductor companies' sales increased almost 300% from \$44.2B to \$172.9B. In 2014, semiconductor sales were the U.S.' third largest export by value (\$43B) after aircraft (\$113B) and automobiles (\$61B). It is estimated that the U.S. semiconductor industry accounts for 250,000 direct U.S. jobs.

Figure 5.2.4 Global 2014 Semiconductor Market Share by Sales



Source: Bloomberg, International Data Corporation

Because much of electronics production is now in Asia, Asia is by far the largest customer of U.S. semiconductor companies, accounting for 62% of U.S. sales with, China representing 31% of all U.S. sales. U.S. companies dominate the Asian market with 55% of the overall market and 59% of the Chinese market. The two weakest U.S. regional market segments are Japan (36% market share) and the Americas<sup>8</sup> (46% market share).

Global semiconductor sales are driven by consumer products such as cell phones, computers, and automobiles. As a result, the industry is driven by volume and technology. In addition, to stay competitive, a significant investment in R&D and new plants and equipment is required. The U.S. semiconductor industry spends more on R&D as a percent of sales (18.4%) than any other U.S. industry. And it spends over 10% of sales annually on capital expenditures.

<sup>7</sup> Semiconductor Industry Association (SIA), "2015 Industry Factbook."

<sup>8</sup> Americas include North, Central and South America

## Budget considerations

Weapons systems do not represent a significant share of the electronics market and therefore reductions in defense budgets do not have a large impact on the industry as a whole. However, specific segments of the supply chain and specific suppliers that rely heavily on the defense market will be hit hard by defense spending reductions.

- Domestic PCB suppliers in particular will be impacted by budget cuts as military and aerospace applications make up 27% of the market for domestic PCBs. Since 2008, PCB demand in the defense segment has declined and can no longer support as many domestic manufacturers. This has resulted in industry consolidation and a reduction in the number of PCB suppliers. Further reductions in DoD budgets will exacerbate the problem.<sup>9</sup>
- Although military electronics are not a large segment of the electronics market, the DoD does spend significant amounts of money on R&D in this area. DoD R&D funding has been increasing as our systems have become more and more reliant on electronics. Despite a declining budget environment, R&D funding in electronics increased in 2014 by 11% from 2013 to approximately \$1.25B. Because the electronics industry is very research driven, R&D funding is one of the only areas where the DoD can influence the industry. Any reductions in DoD R&D spending in this area will have an adverse impact on the industry and diminish any influence that the DoD may have.<sup>10</sup>

## Critical Issues

In October of 2014, IBM agreed to pay GlobalFoundries \$1.5B to take over its semiconductor manufacturing business unit. GlobalFoundries is a multinational semiconductor foundry whose majority shareholder is an Abu Dhabi government-controlled investment fund. IBM is the single source provider of “trusted” application specific integrated circuits (ASICs) to the U.S. Government. The Department is currently in the process of assessing the impact of the acquisition and determining potential mitigation options.

## Long-Term Challenges

The Department currently faces three long-term challenges in the electronics industry: (1) globalization, (2) the rise of China, and (3) commercialization. Although different, these three challenges are interrelated and present similar threats to the Department’s ability to domestically produce weapons systems: denial of access to technology, loss of market influence, increased costs, and untrustworthy supply chains. These challenges have been building for quite some time and will continue to grow for the foreseeable future.

As noted in the industry overview section, much of the electronics industry manufacturing has been outsourced to other low wage countries the majority of which are in

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<sup>9</sup> World Electronic Circuits Council (WECC), "WECC Global PCB Production Report for 2014", WECC, October 2015.

<sup>10</sup> Defense Resource Data Warehouse (DRDW) PB 2014

Asia. This outsourcing has progressed steadily from assembly, to manufacturing, and to design. Today, we have ODMs that produce the entire product while U.S. companies' only value added is marketing. This trend continued in 2014 with notable acquisitions by Lenovo of IBM's low-end server business, and Motorola by Google. A 2014 McKinsey & Company report estimated that "more than 50 percent of personal computers and between 30 and 40 percent of embedded systems (commonly found in defense, automotive, commercial, consumer, industrial, and medical applications) contain content designed in China either directly by mainland companies or emerging from the Chinese labs of global players."<sup>11</sup> The report goes further to conclude that "China could soon influence up to 50 percent of hardware designs globally (including phones, wireless devices, and other consumer electronics)." Given weapon systems' heavy reliance on microelectronics, the continued migration of the microelectronics industry to Asia, in particular China, represents a long-term threat to the nation's ability to continue to produce weapons systems domestically.

As the overall electronics industry has moved to Asia, so too has the PCB industry. In 2014, Asia had a 90% market share in this area, half of which is in China while the U.S. only represented 5% of the market.<sup>12</sup> The small market share of the United States has resulted in the inability of U.S. manufacturers to invest in R&D at the levels required to stay competitive with Asia, particularly in areas related to miniaturization and operating speed/frequency such as microvias<sup>13</sup> and optoelectronic interconnections, respectively. At the same time, the U.S. Government's PCB production capacities also continue to shrink, limiting the Department's ability to sustain systems and acquisition engineering expertise.

So much microelectronics production has been outsourced to China that China was the largest consumer of semiconductors in the world, accounting for 55.6% of global demand in 2013<sup>14</sup> and is the United States' largest semiconductor customer, accounting for almost a third of all U.S. sales. China has long recognized its dependence on imported semiconductors and has tried unsuccessfully several times in the past to develop an indigenous semiconductor manufacturing capability. These efforts have made modest progress but have failed to reduce China's reliance on foreign semiconductors. However, some new approaches may have great impacts:

- In June of 2014, China released a new policy entitled the "National Framework for Development of the Integrated Circuit Industry." The goal of the policy is to increase semiconductor production by at least 20 percent per year and by 2030 be a global leader in all parts of the semiconductor supply chain with several companies in the ranks of globally-leading semiconductor companies. The new policy takes a stronger market-based approach that could have a much better chance of succeeding than past approaches.

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<sup>11</sup> Semiconductors in China: Brave new world or same old story?, Gordon Orr and Christopher Thomas, McKinsey & Co., August 2014

<sup>12</sup> World Electronic Circuits Council (WECC), "WECC Global PCB Production Report for 2014", WECC, October 2015.

<sup>13</sup> Microvias are minute holes drilled by a laser to generate the electrical connection between the layers in a multilayer circuit board.

<sup>14</sup> PriceWaterhouseCoopers – "China's Impact on the Semiconductor Industry" – 2014 Update.

- As part of the new policy, China is establishing a national industry investment fund that will include both public and private funds to increase semiconductor industrial capacity and to implement market consolidation with the aim of creating a viable domestic semiconductor industry. The policy also supports the creation of regional funds and encourages private equity and venture capital funds to invest in the semiconductor sector. Although the policy does not specify a dollar amount to be invested, the Chinese Ministry of Industry and Information Technology (MIIT) has stated that the Chinese Government expects to invest as much as \$19.5B over the next 3-5 years with this funding to be complemented by a series of similar regional equity investment funds.<sup>15</sup>
- Even with these investments, if China is to meet their very aggressive growth targets, it will most likely have to do this through foreign acquisitions rather than internal domestic development. At the same time, because China is the world's largest consumer of semiconductors, it does not need to buy a large amount of market share to be successful. It only needs to create a company with the capacity and capability to service the Chinese market and position it as the national semiconductor champion. It can then divert Chinese semiconductor consumption to this company thereby substantially reducing sales to its foreign competitors.
- A similar strategy has been employed in other sectors with great success. For example, in the telecommunications sector, China championed Huawei and ZTE and directed Chinese business to these two companies. On the strength of Chinese domestic sales, Huawei and ZTE rapidly expanded while once market-dominant North American companies such as Lucent, Motorola, and Nortel either went out of business or were acquired in a relatively short timeframe. Because the U.S. currently dominates the semiconductor market and is very free-market oriented, it is expected that U.S. companies will be the focus of Chinese acquisitions. The Department believes that the number and size of acquisitions will continue to grow.

The semiconductor industry is driven by the commercial sector, consumer electronics in particular. U.S. military requirements represent less than 1% of global demand for semiconductors.<sup>16</sup> The Department, therefore, has very little influence on the semiconductor industry and as a consequence, there is often a large gap between military requirements and industrial capabilities which is a major cost driver in acquiring and maintaining military electronics. The two most notable gaps are in volume and life-cycle time. Commercial volumes are typically several orders of magnitude larger than military volumes. And commercial technology life cycles are typically measured in months whereas military technology life cycles are typically measured in years if not decades. Today, electronic components are often obsolete in the development stage of a program. This becomes a big cost driver in programs.

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<sup>15</sup> Dieter Ernst, "From Catching Up to Forging Ahead? China's Prospects in Semiconductors", East-West Center Working Papers, Innovation and Economic Growth Series, No. 1, November 2014.

<sup>16</sup> Semiconductor Industry Association (SIA), "2015 Industry Factbook."



## Mitigation Efforts

The Department has a comprehensive policy for managing risks to DoD warfighting capability from foreign intelligence collection: from hardware, software, and cyber vulnerability or supply chain exploitation. As codified in DoD Instruction 5000.02, “Operation of the Defense Acquisition System,” November 26, 2013, the Department requires its acquisition programs to produce and maintain robust program protection planning throughout the acquisition life cycle. The Program Protection Plan is the primary means by which the Department is integrating assured microelectronics policy into program management, engineering, and the configuration, parts, and contract management disciplines.

To provide further guidance on this issue the Department has issued DoD Instruction 5200.44, “Protection of Mission-Critical Functions to Achieve Trusted Systems and Networks (TSN),” November 5, 2012, which codifies the Department’s Trusted Defense Systems Strategy. This instruction provides a strategy for acquisition programs to integrate robust systems engineering, supply chain risk management, security, counter-intelligence, intelligence, cybersecurity, software assurance, and hardware assurance (with an emphasis on microelectronics) to manage risks to system integrity and trust. In particular, DoD Instruction 5200.44 provides guidance for managing the risk that foreign intelligence or other hostile elements could exploit supply chain vulnerabilities to sabotage or subvert mission-critical functions, system designs, or critical functions and critical components.

Pursuant to this broad policy, Department engages in several review processes to identify targets for mitigation:

- DoD acquisition programs perform a criticality analysis to identify mission-critical functions and their supporting critical components to determine at-risk information and communications technology that must be assessed and protected. These analyses are documented in the Program Protection Plan. Critical components can be software, firmware, or hardware. DoD systems are typically comprised of numerous microelectronics components, many of which are commercial off-the-shelf products. The protection of critical components can be addressed by supply chain risk management, secure engineering designs and architectures, and other security-related countermeasures. Special attention is given to the subset of microelectronics that is custom-designed for DoD use. For these specific components, the policy requires that “In applicable systems, integrated circuit-related products and services shall be procured from a trusted supplier accredited by the Defense Microelectronics Activity (DMEA) when they are custom-designed, custom-manufactured, or tailored for a specific DoD military end use (generally referred to as ASICs).”
- DMEA manages the DoD Trusted Foundry Program. This program provides the Department, as well as the National Security Agency (NSA) and other agencies, with access to the trusted state-of-the-art microelectronics design and manufacturing capabilities necessary to meet the confidentiality, integrity, availability, performance, and delivery needs of U.S. Government customers. DMEA accredits suppliers as “trusted” in the areas of integrated circuit design, aggregation, brokerage, mask manufacturing,

foundry, post processing, packaging/assembly, and test services. These services cover a broad range of technologies and are intended to support both new and legacy applications; both classified and unclassified. There are currently 67 DMEA-accredited suppliers covering 138 services, including 22 suppliers that can provide full-service trusted foundry capabilities.<sup>17</sup>

- The Department actively monitors transactions in the electronics sector, particularly foreign acquisition of U.S. electronics suppliers. The Department conducts in-depth and comprehensive reviews of these foreign transactions through the Treasury-chaired CFIUS. When appropriate, the Department works with the Committee to mitigate any concerns.
- As directed in the FY09 National Defense Authorization Act, DoD has established the Executive Agent for Printed Circuit Boards and Interconnect Technology (PCB EA) at the Naval Surface Warfare Center (NSWC), Crane Division. The PCB EA provides solutions to ensure that DoD has access to a trusted PCB industrial base by investing at NSWC Crane Division and other DoD activities to sustain DoD organic knowledge and capability of PCBs and related issues.

### **5.2.1 Radar and Electronic Warfare Sector Industrial Summary**

#### Industry overview

Military radar and electronic warfare (EW) systems continue to be upgraded or replaced with Active Electronically Scanned Arrays (AESAs). Industry has been expanding capacity in areas where processes and facilities are specific to AESA. Two facilities have been identified as essential to AESA manufacturing: Semiconductor/Captive Monolithic Microwave Integrated Circuit (MMIC) Foundries that manufacture MMICs; and Micro-Electronic Manufacturing/Assembly Facilities capable of producing AESA solid-state devices such as Transmit/Receive (T/R) Modules, Subassemblies, and Beamformers in Multiple Frequency Bands.

Companies reported<sup>18</sup> that engineering skills specific to AESA development are well staffed and do not anticipate a shortage of any skilled engineering professionals now or in the future. Engineering staffs required for the design/development of AESA products were brought in early in the process and remain today. Most of the skills required in design, manufacture, and testing of AESAs are not unique to the AESA industry. Capacity issues are continually assessed by all manufacturers to assure current and planned requirements can be satisfied. However, rapid swings in requirements (either upturn or downturn) can impose stress on available technically qualified engineering and manufacturing personnel. For this reason, industry employs many strategies to train and maintain its workforce. Some of these strategies include on-site training,

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<sup>17</sup> DMEA Trusted Foundry Program, <http://www.dmea.osd.mil/otherdocs/AccreditedSuppliers.pdf>

<sup>18</sup> “Surface AESA Radar Industrial Base Assessment” (October, 2013) jointly produced by the Office of the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy and the Defense Contract Management Agency/Industrial Analysis Center.

coordination with universities via co-ops and degree programs, certifications for technicians and operators, partnerships with their other manufacturing sites, and working relationships with local contracting firms to provide talent on an as-needed basis. The one specialized skill identified with a long replacement time (12-18 months) was a wafer operator that works in semi-conductor foundries.

Use of common manufacturing processes and specialized work cells leverages the experience and expertise of highly trained personnel and minimizes redundancy in specialized equipment dedicated to particular programs. Resources are easily shared or shifted among various programs to satisfy customer demands. Commonality in hardware also provides leverage and allows for simultaneous scheduling of multiple programs. Trends toward commonality in hardware have also increased the use of specialty shops or centers of excellence such as machining, electronics, and fabrication. Most prime system integrators use a captive manufacturing process drawing on the expertise of sister facilities located throughout the country, and/or the world, to provide additional support and address capacity issues.

In 2014 there continued to be three domestic prime manufacturers for radars – Raytheon, Lockheed Martin, and Northrop Grumman, and four domestic prime manufacturers for EW – Raytheon, Northrop Grumman, ITT, and BAE Systems. With several full rate production (FRP) programs previously developed for AESA upgrades to air, sea, and land systems, as well as foreign sales, the industrial base appears to be viable and stable. However, in 2014 there were only two programs in the Engineering and Manufacturing Development phase and two in low-rate initial production (LRIP): Raytheon is developing the Air and Missile Defense Radar (AMDR) for the Navy; Lockheed Martin is developing the Space Fence for the Air Force; Northrop Grumman has entered production of the Ground/Air Task Oriented Radar (G/ATOR) for the Marine Corps; and production of Block IV of the Integrated Defensive Electronic Countermeasures (IDECM) is being performed for the Navy by ITT (producing the jammer) and BAE Systems (producing the external decoy).

#### Budget considerations

Radar makes up only a small part of the electronics market and AESA makes up only a small part of the radar market, so a downturn in funding for AESA systems will not affect the overall market. Table 5.2.1.1 shows the 2014 funding for radar and EW. There is little change in overall spending compared to 2013.

Table 5.2.1.1: 2014 Funding for Radar and EW TY \$M				
<b><u>Program</u></b>	<b><u>RDT&amp;E</u></b>	<b><u>Procurement</u></b>	<b><u>Total</u></b>	<b><u>% Change from 2013</u></b>
AMDR	112.7	0	112.7	-41.9
G/ATOR	74.4	93.7	168.1	7.3
Space Fence	279.3		279.3	37.2
IDECM	13.5	100.0	113.5	5.8
TOTAL	479.9	193.7	673.6	1.8
Source: Selected Acquisition Reports (March, 2015)				

### At-risk areas

Key components for AESAs are ceramics packaging and MMICs. Prior to 2000 the manufacturing infrastructure for ceramic packaging was quite robust. High Temperature Co-fired Ceramics (HTCC) and Low Temperature Co-fired Ceramics (LTCC) are critical technologies for AESA systems. The HTCC and LTCC domestic supply base was served by several manufacturers when many of the AESA electronic packages were in development. However, there has been a downsizing in the HTCC supply base through mergers and acquisitions in recent years. Kyocera in San Diego, CA, which is a subsidiary of Kyocera, Japan, currently supplies the bulk of the HTCC electronic packages for AESA systems. The materials development and package design takes place in Japan. The LTCC package manufacturing infrastructure has undergone similar downsizing. Today, the domestic market is served by three suppliers, Kyocera, Natel Engineering, and Anaren Microwave. Natel Engineering and Anaren are U.S. based companies with Natel Engineering supplying the bulk of the LTCC packages to AESA systems. Most of the manufacturing infrastructure and materials development in LTCC is taking place in Asia to serve the commercial industry. The outlook for the competitive supply of domestically produced ceramic packages is not favorable.

The main suppliers for MMICs are TriQuint in Richardson, TX and Cree in Durham, NC. However, almost all of their output is for the commercial market. Japanese and Korean companies have introduced competitive GaAs and Gallium Nitride (GaN) technologies that have the potential to transform the MMIC supply base similar to what has occurred in the packaging supply base.

### Long-Term Challenges

The primary challenges AESA technology encounters in today's marketplace are: affordability, increased foreign competition, and limited access to foreign markets by U.S. firms. Companies report that, until recently, the U.S. had maintained a lead in defense technology development and capability. Over the past decade the gap in these two areas has decreased. This

is highlighted by the fact that, as recently as 10 years ago, the U.S. provided the majority of defense systems sought by our foreign allies and partners. This position is changing. In 2010, European and Israeli defense companies accounted for greater than 50% of the sales in the non-U.S. defense electronics market. These increased sales by foreign companies highlight improved foreign technical capabilities. U.S. capabilities remain superior, but international customers appear satisfied with an 80 percent solution. As a byproduct, the expansion of sales will provide investment funds for further development. In the past, these same countries' weak economies and struggling defense industries severely limited defense product development. Since 2000, defense companies have proliferated globally, maturing and creating new and advanced products. This is due to allied/partner ambition to build organic capacity and boost defense export. Beyond enhancing competition, the making of sales to countries with burgeoning defense electronics industries will require co-development and an increased amount of technology transfer. European defense firms are now multi-domestic and may become multi-national in the future.

### Mitigation Efforts

Mitigation is focused on rebuilding the domestic supply base lost through recent industry consolidations. There are currently two ongoing Title III projects relevant to the technologies utilized in AESAs. These are the following:

- Gallium Nitride Radar and Electronic Warfare Monolithic Microwave Integrated Circuit Producibility Project – This \$35.4 Million project seeks to increase the yield, affordability, and availability of GaN S-Band and MMIC produced on 100 mm Silicon Carbide substrates to ensure domestic availability of these devices for next generation defense systems.
- Gallium Nitride Advanced Electronic Warfare Monolithic Microwave Integrated Circuit Producibility Project –This \$8.6 Million project seeks to establish a domestic, economically viable, open-foundry merchant supplier production capability for Ka-band GaN MMICs.

## **5.2.2 Command, Control, Communications, and Computers (C4) Sector Summary**

### Industry overview

Wide varieties of vendors are qualified to design and build an array of defense products within the C4 industrial sector. A robust global commercial electronics industrial base supports these vendors. Second-tier suppliers of assembled components tend to serve both commercial and defense customers. Third-tier suppliers of individual components, such as integrated circuits, frequently supply identical products for both commercial and defense use. At the fourth-tier, such as design tools and reused intellectual property, there is frequently minimal awareness of the final end use in defense products. In essence, the C4 industrial base upon which the Department typically relies is largely global below the prime contractor tier.

DoD's C4 capabilities are frequently incorporated as subcontracts under a platform prime contractor though at times C4 capabilities are acquired directly by the Department as stand-alone projects.

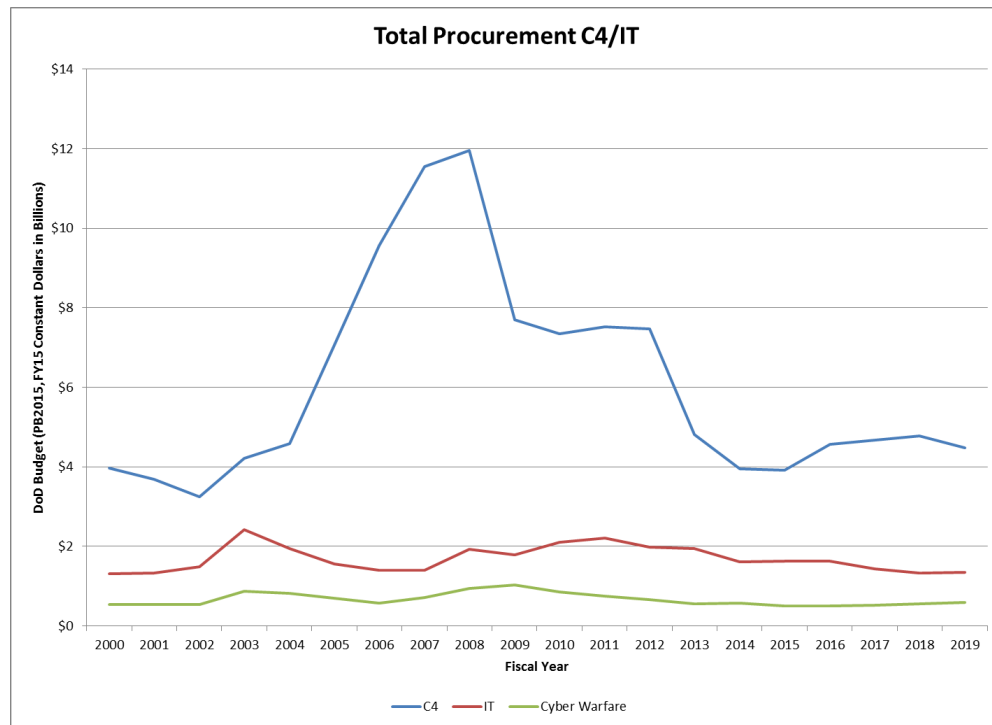
Table 5.2.2.1: C4 Programs and Major Prime Contractors

Major C4 stand-alone Programs	Major C4 Prime Contractors
B-2 Defensive Management System Modernization	Northrop Grumman
Cooperative Engagement Capability	Thales
F-15 Eagle Passive Active Warning Survivability System	Raytheon
Integrated Air & Missile Defense	Boeing
Joint Precision Approach and Landing System	ATK
Joint Tactical Radio System	Lockheed Martin
Handheld, Manpack, and Small Form Fit Radios	General Dynamics
	Harris
	ITT Excelis
	BAE
Multi-Functional Information Distribution System	
Navy Multiband Terminal	
Warfighter Information Network-Tactical Inc 2	
Warfighter Information Network-Tactical Inc 2	

### Budget Considerations

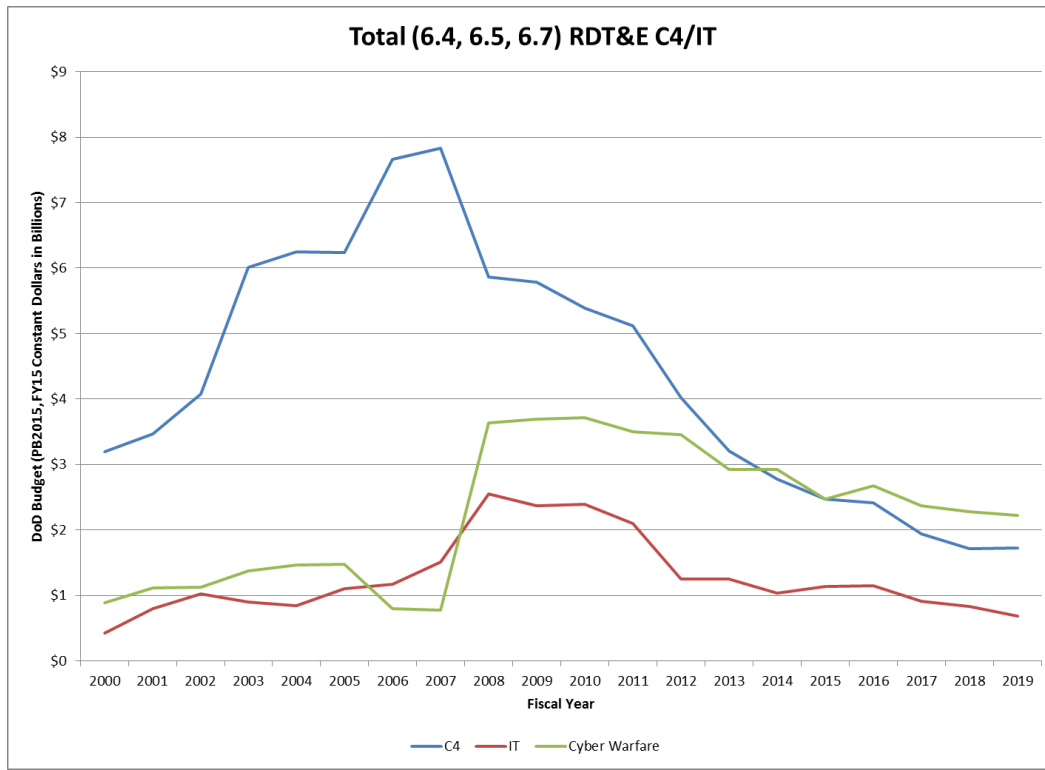
While both procurement and RDT&E declined significantly for the C4 sector, because of the depth and breadth of the industry as well as the support of the commercial C4 industry, DoD does not have major concerns for the sector related to the downturn. There are a number of other concerns, unrelated to budget, discussed above in section 5.2.

Figure 5.2.2.2: Total Procurement C4/IT



Source: Defense Research Data Warehouse

Figure 5.2.2.3: Total RDT&E C4/ IT



Source: Defense Research Data Warehouse

### *Joint Precision Approach and Landing (JPALS).*

In 2013, the Navy performed an internal analysis of the overall Department of the Navy Precision Approach and Landing Capability (PALC) requirements. The result of the internal analysis was a Navy proposal to accelerate the incorporation of capabilities planned for future increments, which would have been separate Acquisition Category (ACAT) I programs, into the JPALS program. Under this concept, the JPALS ship system will continue to be developed for auto-land and procured for use on Nuclear Aircraft Carriers (CVN) and Amphibious Assault (LH) type ships in support of the F-35B/C and Unmanned Carrier Launched Airborne Surveillance and Strike (UCLASS) programs. The Navy also determined that legacy aircraft would no longer be retrofit with JPALS, but will use current legacy landing systems.

All of the changes culminated in a critical Nunn-McCurdy unit cost breach to the Program Acquisition Unit Cost (PAUC) and Average Procurement Unit Cost (APUC) in the JPALS Inc 1A APB. A program deviation report was signed by the PM on January 28, 2014, and was endorsed by the Navy Acquisition Executive and forwarded to the Milestone Decision Authority (MDA) on March 12, 2014. The Secretary of the Navy notified Congress of the breach on March 19, 2014. On June 15, 2014, USD(AT&L) provided direction to the Air Force for the restructured JPALS program, which certified the program in lieu of termination. Accordingly, the JPALS Milestone B decision of July 2008 was rescinded. JPALS was directed to continue auto-land trade studies and risk reduction efforts through the 3rd Quarter of FY 2016; and return

to the DAB for Milestone B approval for the restructured JPALS program not later than the 3rd Quarter of FY 2016.

### *Joint Tactical Radio System*

In the September 2014 Selected Acquisition Report (SAR), JTRS Handheld, Manpack & Small Form Fit (HMS) identified both a PAUC and an APUC increase over the Current Baseline Estimate of greater than 15%, signifying a Significant Nunn-McCurdy Breach. A Program Deviation Report was signed by PEO Command, Control, and Communications - Tactical on March 25, 2014 also identifying this breach. The program has since undergone extensive cost model analysis, revision, and procurement strategy updates working with Deputy Assistant Secretary of the Army for Cost and Economics and other agencies. The results from the updated cost model no longer reflect a Nunn-McCurdy Breach.

### Mitigation

The DoD Title III program had three C4-related projects in 2014.

- 1) Low Cost Military Global Positioning System (GPS) Receivers Project. Military GPS receivers are vital equipment on the battlefield as they enable warfighters to perform strategic and tactical maneuvers with a high degree of confidence and success.
- 2) Small Secure Satellite Communication (SATCOM) Transceiver Project. This Title III project established a domestic capability for the manufacture of small secure software-definable SATCOM Transceivers with the latest technology.
- 3) Three Dimensional Microelectronics for Information Protection Project. Many of the DoD's most sophisticated weapon systems and communications systems, by their very nature, are operated in close proximity to enemy combatants.

## **5.3 Ground Vehicles Sector Industrial Summary**

### Industry overview

The Ground Vehicle sector is generally categorized in two broad vehicle classes: tactical wheeled vehicles (TWV) and combat vehicles. The TWV are usually trucks modified from commercial variants and specifically designed to accommodate use in demanding military environments/missions. This class has a higher potential to benefit from dual-use or commercial business. Combat vehicles are typically heavily armored and integrated with complex weapons systems, fire control and sensors. This class of military ground vehicles tends to be defense-unique with little commercial application.

Both classes of ground vehicles experienced a significant surge in production and development during the wars in Iraq and Afghanistan. In addition, periodic upgrades were required to leverage advanced technology to address evolving war-fighting needs. Today, despite U.S. troop reductions in both theaters, there is a continuing need to sustain the unique manufacturing capabilities and supporting supply chains established during the wartime surge.

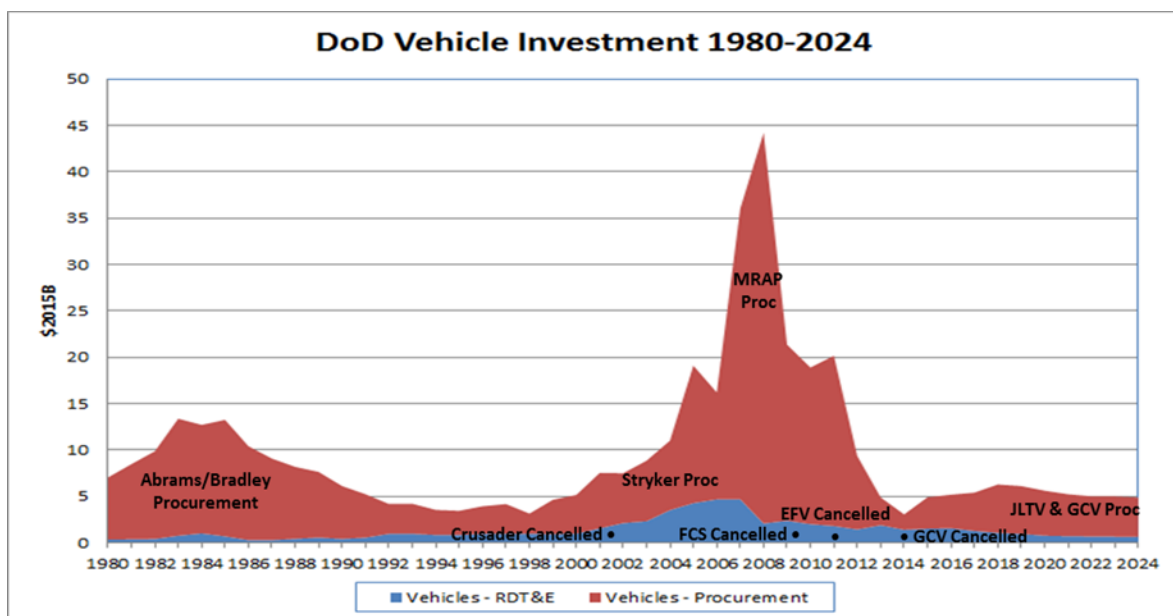


Sustainment will provide for the overhaul and recapitalization of the wartime fleet, preserve equipment readiness in the event of a resumption of hostilities, and support continued equipment design and development needs.

### Budget Considerations

For the past few years, DoD budgets to support ground vehicles have remained down. This is true in both the procurement and research, development, technology and engineering (RDT&E) funding profiles (as illustrated by the graphs in Figure 5.3.1 below). Overall funding was reduced by approximately 15 percent for FY14-19. This reduced level of funding in this sector hasn't been seen since the mid-1990s.

DoD Vehicle Investment Figure 5.3.1



Source: Defense Research Data Warehouse

With these low budgets, the Services have focused investments on 1) modernizing the current legacy vehicle fleets at the cost of delaying new development, and 2) increasing Foreign Military Sales. Listed in Figure 5.3.2 are the major legacy and development Combat Vehicle programs with their corresponding prime contractor. Of note is the cancellation of Army's Ground Combat Vehicle (GCV) and the Marine Corps Expeditionary Fighting Vehicle (EFV) development programs, which resulted from the Service's constrained budgets and future affordability. To meet budget and readiness objectives, the Services turned towards a strategy of investing in upgrades to current fleets and cancelled development programs.

The Department's industry partners in the ground vehicle markets are faced with challenges associated with these reduced budgets; many have reduced output to or below their minimum sustainable rates and production levels. This environment requires the Department to deliberately assess and mitigate the critical industrial base risks to maintain the viability of the

ground vehicle sector. The Services, MIBP and other stakeholders continue to monitor and assess these segments of the ground vehicle base to identify at-risk capabilities.

Contractors and Platforms Figure 5.3.2

Current Contractor	Vehicle	Type	Service	Fielded
BAE	AAV-P7/A1	Tracked	USMC	Yes
	AMPV (M113 Replacement)	Tracked	Army	No
	Bradley Fighting Vehicle (BFV)	Tracked	Army	Yes
	M88 Hercules	Tracked	Army	Yes
	M109 PIM	Tracked	Army	Yes
GDLS	Abrams Tank	Tracked	Army/USMC	Yes
	EFV (Formerly AAV) Upgrade of AAV-P7/A1	Tracked	USMC	No Cancelled
	Stryker	Wheeled	Army	Yes
LMMFC	MPC (Havoc) Or AMV (Havoc)	Wheeled	USMC	Yes
BAE/GDLS	GCV (Bradley Replacement)	Tracked or wheeled	Army	No Cancelled
BAE/GDLS/ SAIC/LMMFC	ACV 1.1	Wheeled	USMC	No Pre-MDAP

### Risk Assessments

While declines in the ground vehicle sector are expected to continue, companies that service both the commercial and military markets (dual-use) are expected to fare better than those in military-unique niches. Companies reliant on DoD business and whose portfolios have no commercial applicability, or lack an ability to diversify, potentially manifest more risk based on their defense unique characteristics and will likely have to continue to consolidate facilities and reduce their workforces.

#### *Tactical Wheeled Vehicles:*

The Army (PEO CS/CSS) conducted a deliberate assessment of the TWV industrial base in FY14 to determine any significant IB risks in this sub-sector of the military ground vehicle fleets. All TWV suppliers were assessed at moderate or lower risk. This assessment is expected to be similar for all Services as the primes/suppliers analyzed are consistent across joint programs. Analysis also concluded the majority of TWV suppliers would be minimally affected by reduced DoD purchases/ workload, due to the dual-use and commercial nature of the TWV class of military vehicles, and TWV supplier ability to leverage their commercial sales.

Within the TWV class of military ground vehicles, the final (single-source) award of the Joint Light Tactical Vehicle (JLTV) is likely to have a market impact. Three companies were awarded EMD contracts: AM General, LLC; Lockheed Martin Corporation; and Oshkosh Corporation. The final award (valued at over \$450 Million in PB16 and potentially Billions of dollars over the vehicle's lifecycle) has potential to impact future and legacy fleets.

#### *Combat Vehicles:*

This sector faces a number of industrial base challenges including retaining critical design and integration engineering talent and sustaining critical suppliers in the sub-tier industrial base. As budgets are increasingly constrained, investments in ground vehicle research and development (Figure 5.3.3 - RDT&E funding) are also projected to continue to decline. In addition, the cancellation of the GCV program resulted in the Services having no new systems development programs in the combat vehicle sector.<sup>19</sup>

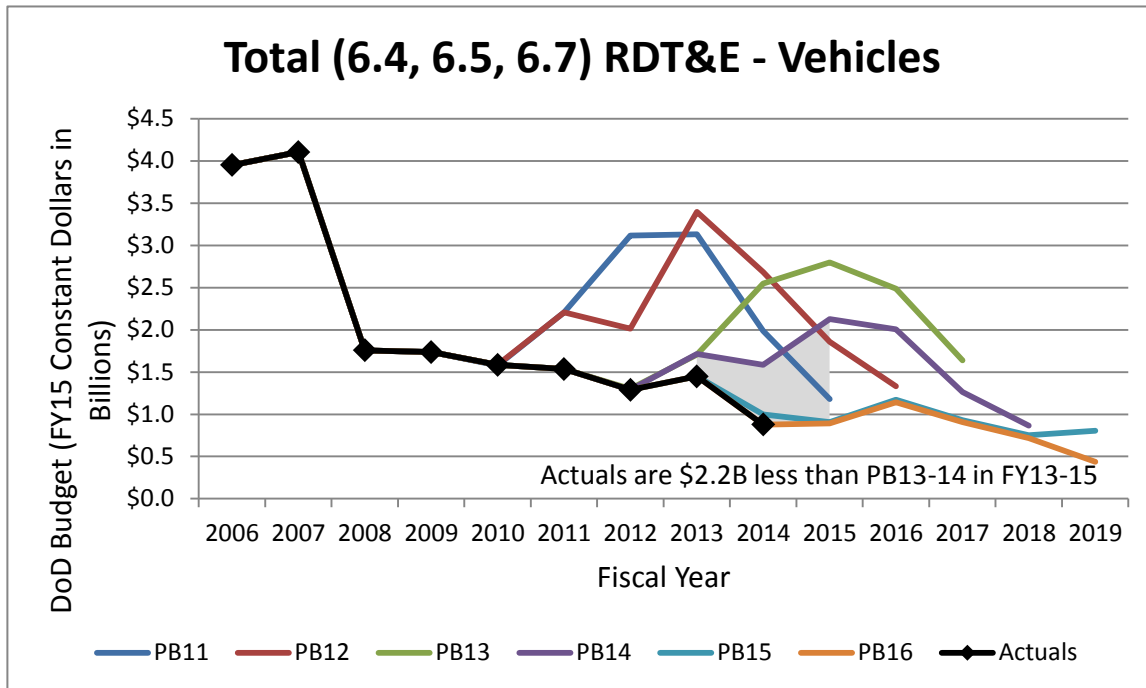
Specific to design and engineering risks, MIBP requested that DCMA assess current risks to the combat vehicle design skills segment. Results of the November 2014 DCMA assessment determined that Service's efforts to upgrade legacy fleets with component level improvements only partially sustained core skills. In several instances, the skilled worker was retained, but not actively engaged in a fulltime design/engineering capacity. This scenario could potentially lead to attrition of capability. However, DCMA also determined that accelerating development of a full, systems-level prototype was not immediately necessary to retain the capability for combat vehicle systems design and engineering.

The highest risks encountered were in the component supplier base and not within the prime contractors. The Department remains concerned that the design engineering capabilities needed for these systems may not be readily available should the skill atrophy in the absence of demand. Army PEO-GCS, in coordination with MIBP and the DCMA, is analyzing specific risks in this area and to identify potential mitigation options to inform strategies for POM 17-21 review.

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<sup>19</sup> Armored Multi-Purpose Vehicle-AMPV, Amphibious Combat Vehicle 1.1- ACV 1.1, and PALADIN Integrated Management-PIM acquisition strategies leverage already demonstrated technology.

RDT&E Figure 5.3.3



Source: Defense Research Data Warehouse

### Mitigation Needs

A 2014 Army study to analyze the Combat Vehicle supply chain—identified two specific component areas as critical and fragile, requiring additional analysis and potential mitigation. The two areas were vehicle Transmissions and Forward Looking Infra-red (FLIR) sensors. FLIR sensors are a ubiquitous component/capability resident on multiple DoD platforms and systems, and cross-cut several sectors, e.g., Space, Missiles, Fixed-wing and Rotary Aircraft, as well as Combat Vehicles.

*Combat Vehicle Transmissions.* The combat vehicle transmission industrial base currently consists of three key DoD suppliers: Allison Transmission, L-3 Combat Propulsion Systems, and Twin Disc. These companies are single qualified transmission suppliers with a unique product line for specific vehicles. In light of projected budgets, current declining transmission demand will likely remain unchanged. This presents potential risk to our suppliers as projected demand falls below their minimum sustaining rate (MSR) requirements.

The Army's 2014 Preliminary report to Congress on the Combat Vehicle Transmission Industrial Base Assessment determined that the incumbents' current business state presented a number of risks. These risks were based on diminished production rates and facilities that had been sized based on higher production rates. These suppliers are now challenged with allocating fixed costs across a smaller product base, which could threaten their ability to sustain production based on DoD contracts alone. The ultimate DoD industrial base risk in this situation is that a current, sole-source supplier decides to leave the market.

Current on-hand assets and rebuild capability buffer some of this risk. At the same time, costs to engineer/reverse engineer replacements and the time necessary to requalify new suppliers may be more costly or a greater risk than direct investment in incumbent suppliers. There appear to be multiple companies, international and domestic, that have the capability to enter into this segment. There are several options and actions being considered: (1) Direct investment to maintain a minimum capacity at the key suppliers, (2) Work with suppliers to develop a more favorable business model, (3) Continue S&T on new transmissions concepts, (4) Develop second sources for key components and systems using both the commercial and organic industrial assets, and (5) Develop alternative transmissions that can replace current products.

The current environment of reduced DoD budgets and the relatively solid state of readiness for the legacy ground vehicle fleets will likely result in a continued trend of reduced investments. Within the Defense-unique suppliers, the reduced investments translate to reduced production volumes that may be below minimum sustaining rates, forcing industry to make decisions on whether to stay in the Defense market. This presents potential industrial base risks that the DoD must be able to assess and address. The Department will continue to monitor these potential at-risk areas through industrial base assessments and will consider mitigation necessary to preserve critical suppliers and skills that may be adversely affected by reduced demands.

## **5.4 Materials Sector Industrial Summary**

### Industry overview

Access to the basic materials required for producing finished and intermediate products and components, including robust and diverse materials supply chains, is integral to the nation's manufacturing base and the nation's overall economic and national security. Typically, materials supply chains rely on considerable international trade, including basic raw material inputs through intermediate and fabricated materials products. In general, globalization results in lower costs, more efficient supply chains, and access to more resources. However, it may also create a dependency on foreign resources which could be subject to a range of actions which distort supply chains and price structures such as export controls and differing approaches to the regimes governing mining (e.g. production controls, permitting) and investment activities. Difficulties obtaining the necessary permits and accessing sufficient capital to start a mine in the United States remain impediments to the establishment of robust domestic supply chains for certain materials (e.g. rare earths). On the other hand, there are materials industries with established domestic supply chains which are generating substantial revenues and profits (e.g. beryllium, titanium).

Generally, the requirements of the defense industrial base represent a small percentage of overall U.S. demand for materials, such that U.S. consumption and supply chains are focused on serving the needs of the commercial sector. Therefore, maintaining a vibrant commercial manufacturing base is essential to the health of the defense industrial base. However, the Department closely monitors the materials required by the defense industrial base and their supply chains, especially for those materials where there may not be a strong demand impetus

from the commercial sector. Given these dynamics, the Department's concern regarding materials has increasingly shifted away from the mined raw material and has moved toward chemicals, compounds and semi-finished manufactured goods.

### Critical issues

Among the many materials serving as inputs to the defense industrial base, the availability of rare earth materials continues to garner considerable concern. Since the Department's initial rare earths report to the Congress in 2011,<sup>20</sup> increased market supply from a more diversified producer base coupled with decreased demand has resulted in global surpluses for several rare earth materials. However, despite additional new U.S. capabilities over this time period, gaps remain in the domestic supply chain. For instance, facilities in China, Europe, Japan, Philippines, and Vietnam maintain roles in the complex supply chain that provides intermediate and finished rare earth products to the U.S. market. The U.S. rare earth industry is caught in a classic "chicken and egg" dilemma consisting of whether the development of an upstream sector (e.g. mining and oxide production) will spark the growth of a downstream sector (e.g. metals, alloys, magnets), or whether a downstream sector needs to develop first in order to generate sufficient demand for raw materials to justify the development of the upstream sector. In either case, and especially for the upstream sector, access to capital is a key issue.

### Risk Assessment

The Department notes that the supply of rare earth materials for U.S. defense acquisition programs is not presently disrupted. The Department estimates a gross defense shortfall (i.e. before any market mitigating factors) only for high purity yttrium oxide from among the rare earths, and the Department already has sought and received authority from Congress to acquire this material for the National Defense Stockpile (NDS). The Department also indicates that defense shortfalls exist for seven other materials (when considering all carbon composite materials identified as a single material) due to single-source foreign production or domestic single points of failure (as required by the amended Stock Piling Act, e.g. beryllium, rare earth elements). When market responses are insufficient to eliminate a shortfall, the Government may act to address the shortfall through a number of available authorities including the Defense Priorities and Allocation System, Title III of the Defense Production Act, the Department's Manufacturing Technology Program, and the National Defense Stockpile.

### Mitigation strategy

MIBP coordinates with agencies within the DoD (e.g. DLA Strategic Materials) as well as interagency (e.g. U.S. Trade Representative, White House Office of Science and Technology Policy) to address the issue of materials availability holistically. Such efforts seek to identify materials of concern to national security (including as it relates to economic growth), assess the ability of the supply chains for these materials to meet U.S. industrial base requirements, and develop strategies to ensure their availability (e.g. successful WTO case per Chinese export

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<sup>20</sup> Interim Report, Assessment and Plan for Critical Rare Earth Materials in Defense Applications, from USD (AT&L) to the Congress, August 2011.

controls on rare earths, tungsten and molybdenum). For example, the Department of Energy's Critical Materials Institute focuses on technologies which make better use of materials and eliminate the need for materials which are subject to supply disruptions. The Institute focuses on materials which are essential for American competitiveness in clean energy. However, efforts which enhance the supply chain overall will benefit the defense industrial base as well. The Institute is currently concentrating their research on the rare earths dysprosium, terbium, europium, neodymium, and yttrium, as well as lithium and tellurium.

### Long-term challenges

The defense industrial base is dependent upon a wide variety of materials, many of which are derived from geologic resources. The United States maintains significant undeveloped natural resources which could contribute to a secure source of supply for the defense industrial base. In fact, according to the 2013 Annual Survey of Mining Companies by the Fraser Institute Alaska and Nevada rank first and third in the world for perceived geologic potential. Unfortunately, the global mining industry does not view the United States overall as an attractive jurisdiction for the exploration and development of mines which will yield future production. Wyoming and Nevada are the only two states among the top ten jurisdictions in the Fraser Institute's policy perception index – a metric which addresses, among other things, the perceived uncertainty regarding a jurisdiction's regulatory, tax, land use, and legal systems. The Fraser Institute's Investment Attractiveness Index, which combines geologic and policy perception, includes only Alaska and Nevada among the top ten jurisdictions. Also among the top ten are four Canadian jurisdictions and three Nordic. This would seem to indicate that investment gravitates to Canada rather than the United States and that environmental regulation in other jurisdictions (which are similar to or even exceed those of the United States) do not appear to be an impediment to mining in those other jurisdictions. The efficiency with which the United States federal and state governments review environmental impact statements and other required documents compared to jurisdictions in Canada and the Nordic territories may, in part, explain this discrepancy.

## **5.5 Munitions and Missiles Sector Industrial Summary**

### Industry Overview

The munitions and missile industrial sector is comprised of DoD's smart bombs, tactical (cruise missiles, air-to-air, air-to-ground, surface-to-air), missile defense, and strategic missiles, as well as dumb bombs, ammunition, mortars, and tank rounds. The munitions and missiles industrial sector is primarily a defense-unique industrial sector. Since most/all of the major issues lie within the missile industrial base, dumb bombs, ammunition, mortars, and tank rounds, are not included in this report.

The Department provides the necessary resources to the industrial sector to ramp up production for munitions and missile systems to support Warfighter needs when the country is engaged in conflict, and it reduces the resources when the conflict ends. This cycle of rapid ramp-ups followed by precipitous declines of demand and production adds significant capacity management challenges to munitions and missile suppliers and their critical sub-tier suppliers.

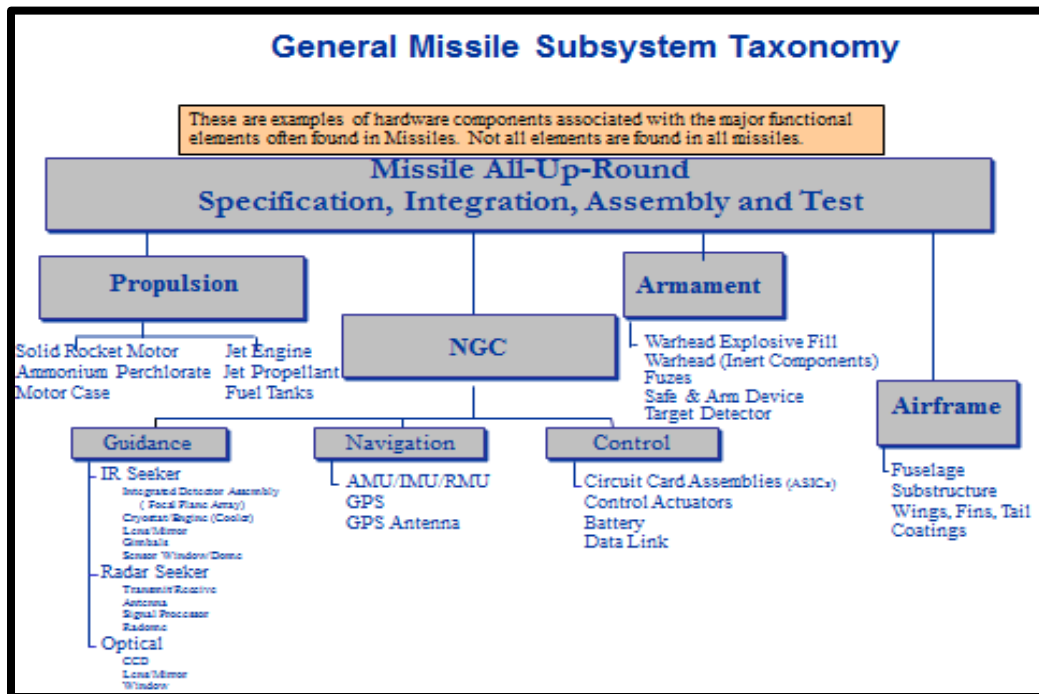
While all industrial sectors are challenged by rapid changes in DoD demand, this ramping up and down based on global conflicts increases risk for defense-unique industrial sectors at the sub-tier supplier level because many do not have the diversity of programs or products from other non-defense markets to support their design and production skills, and the sub-tier suppliers do not have the backlog of business.

Over the past decade, the munitions and missile sector has provided no new-start missile opportunities, as all ‘new’ missile programs have been upgrades to existing systems. This sector is also currently undergoing a decline in procurement. Therefore, the design and production skills for critical components within the missile sector industrial base are at risk. The loss of this design and production capability could result in costly delays, unanticipated expense, and a significant impact to many current and future missile programs, damaging the readiness of the Department and negatively impacting a foundational national defense priority by placing our ballistic missile production capability at risk.

The general missile taxonomy shown in Figure 5.5.1 breaks the missile into four functional areas: propulsion, armament, airframe, and navigation, guidance, and control (NGC). In the propulsion area, most missiles use a solid rocket motor (SRM). The size of these motors can range from 2.75 inches in diameter to as large as 83 inches for some strategic and ballistic missile defense systems. Some tactical missiles, like the Tactical Tomahawk, use a jet turbine fan engine. The major distinction for the warhead is either nuclear or conventional. The airframe area includes the fuselage, wings, fins, tail, and substructures. The airframe materials for these components range from aluminum to complex composites. The NGC area, in many cases, comprises the most expensive components of the system (mostly missile seekers).



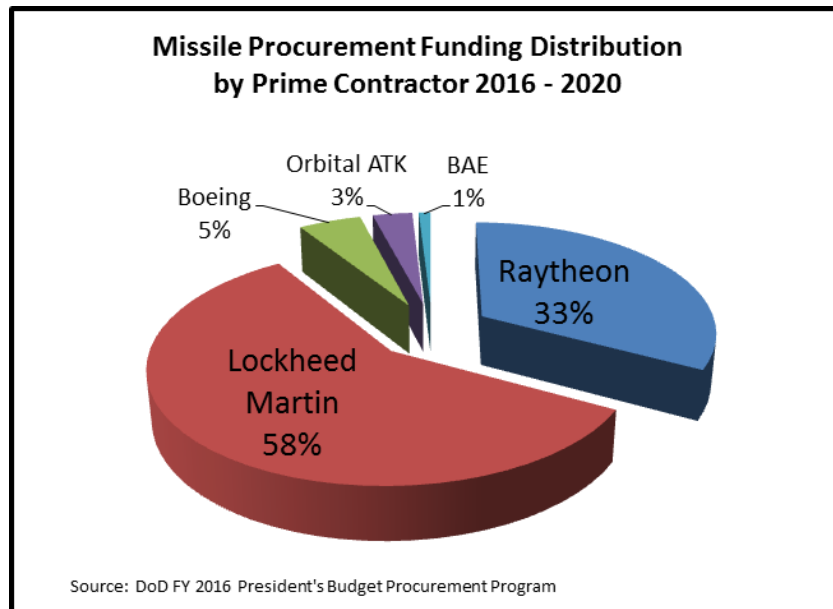
Figure 5.5.1



### Prime Contractors.

Since the end of the Cold War, the munitions and missiles development and production market has declined, resulting in aggressive competition for limited new program opportunities. Within the munitions and missile sector, two prime contractors, Raytheon Missile Systems (a division of Raytheon Company) and Lockheed Martin Corporation account for roughly 90 percent of the Department's munitions and missile procurement funding, as indicated in Figure 5.5.2. These prime contractors provide a full complement of missile types across the munitions and missiles sector and, for the most part, are able to meet defense-unique technical performance requirements, but not without concerns. DoD's prime contractors and their associated sub-tier supplier base must align company production capacities with expected DoD budget realities while ensuring the industrial capabilities needed for the next generation weapon systems are sustained.

Figure 5.5.2



### Budget Considerations

As seen in Figure 5.5.3, RDT&E budgets for tactical missile programs drastically declined from 2010 to 2014. And although the PB16 data is showing an increase from 2015 to 2017 (with another decline in 2018 to 2020), history has shown that these increases usually do not remain in the budget in the out-years. Over the past several decades, the DoD has provided limited new-start missile opportunities. Most recent “new start” missile programs such as the Joint Air-to-Ground Missile (JAGM) have been converted to or designed as slight modifications of existing systems (new seeker for Hellfire in the case of JAGM) versus actual new missile designs. This does not allow the design, development, and integration skills within the tactical missile industrial base, and specifically the SRM industrial base, to be exercised, and limits competitive opportunities. The skill set necessary to design, develop, prototype and test a new missile is very different from the skill set for producing an existing missile. Most DoD tactical missiles have been produced for many years or even decades, and have reached steady state, limiting opportunities for industry to hone its design capabilities. Increases in the strategic missile RDT&E budgets are due mostly to the Ground Based Strategic Deterrent (GBSD) program, the LGM-30G Minute Man III replacement program.

Figure 5.5.3

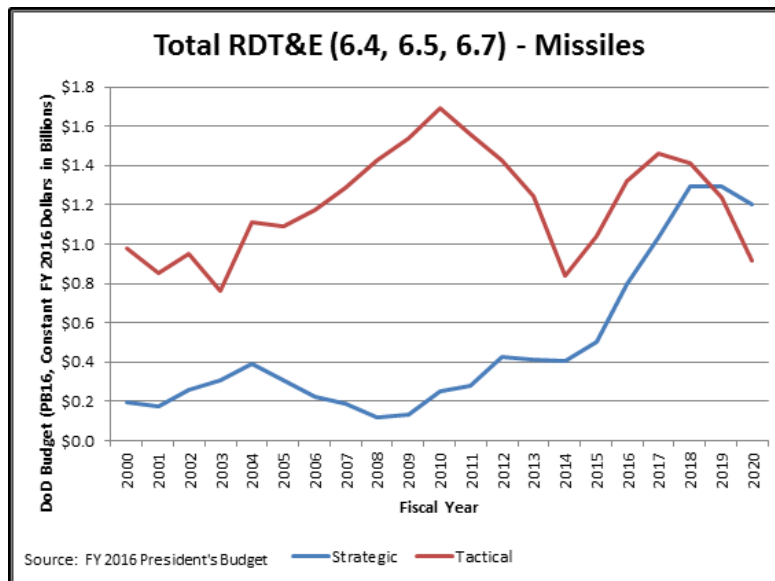
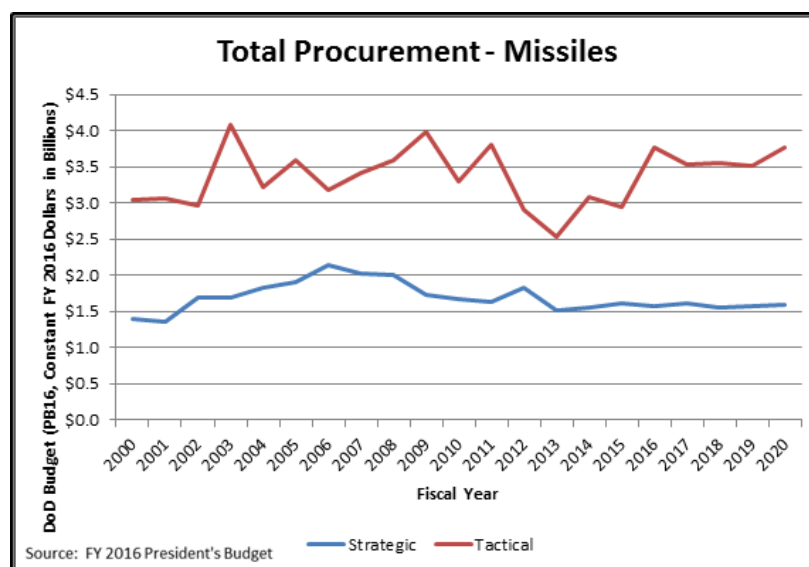


Figure 5.5.4 indicates that procurement budgets for strategic missiles appear fairly steady, however, funding for specific missile programs can increase and decrease dramatically as inventory and usage demands change. This creates stress on the missile industrial base, and especially on the smaller sub-tier suppliers, who must figure out a way to remain viable in low production environments, while remaining ready to ramp up production when needed. The tactical missile procurement numbers fluctuate greatly, and have recently (2011 to 2014) seen a significant decline. Again, although there appears to be an increase starting around 2015, it remains to be seen whether this increase will remain in the out-years.

Figure 5.5.4



## Industrial Assessment

The munitions and missile industrial sector is routinely impacted by significant shifts in DoD demand as a result of various factors, but mostly due to the initiation or drawdown of conflicts. The Department is concerned with the ability of our munitions and missile prime contractors to manage and sustain critical sub-tier suppliers during these shifts in demand. Some of these critical sub-tier suppliers are single or sole-source providers, and some are foreign. As the Department draws down its operations overseas, it is monitoring the impact of reduced demand on the sub-tier supplier base through continuing FaC assessments of the DIB in close cooperation with the Military Departments. The Department expects to identify a growing number of industrial capability risk areas as sub-tier suppliers realign and adjust their industrial capacities to new DoD budget realities.

Due to the recent budget uncertainty MIBP performed a FaC assessment of the missile industrial sector. MIBP collaborated with the DoD Fuze IPT and the Critical Energetics Material Working Group for valuable industry and product information in their respective industrial sectors. The health of sub-tier suppliers in defense-unique fields is a serious and valid concern. Important defense unique sub-tier components in the munitions and missile industrial segment that continually face excess capacity challenges include thermal batteries, solid rocket motors, fuzes, jet engines, inertial measurement units (IMUs), GPS receivers, seekers, and warheads. The suppliers that provide these components are used on multiple programs, and some of these components require 12 months or more to manufacture. Some of these sub-tier supplier products have broader utility and commercial applications that provide a more reliable and stable market base to sustain industrial design and production capabilities – such as the IMUs, GPS receivers, and seeker product sectors – while others are more unique to the munitions and missile industrial sector.

As DoD budgets become even more strained by higher priority needs like operational readiness, aircraft, and ship procurements, investments in munitions and missile R&D and procurement may be further reduced. The results of the Missile FaC assessment confirmed previously known industrial base challenges. These challenges fall into two broad categories; (1) sustaining our design and engineering teams and (2) sustaining the sub-tier supplier base.

The following industrial base sub-sectors continue to be identified as the industrial areas with the highest risk:

- *SRMs*: SRMs are predominantly defense-unique items. The certainty of demand is at-risk because munitions and missiles are often used as bill-payers in fiscally constrained environments. The challenge is the high cost for reconstitution should the SRM industry encounter a significant production gap, particularly in the large (over 40-inch diameter) segment of the market. NASA's retirement of the Space Shuttle and the transition of the Constellation program to the Space Launch System have resulted in significant under-utilization of existing capacity.
- *Thermal Batteries*: All DoD missiles and Precision Guided Munitions use thermal batteries. Thermal batteries are predominantly defense-unique items and the domestic

thermal battery industry has historically been dominated by one company with little participation by other firms. The other domestic companies that produce thermal batteries constitute less than 20 percent of the DoD thermal battery market. The dependency on a dominant supplier of thermal batteries makes this industry at-risk.

- *Fuzes*: Fuzes are defense unique-items, they are used on all munitions and missile programs. Continued improvements in guided systems significantly reduced the quantity of fuzes required for our current and future systems. This has contributed to an excess capacity in the fuzes sector. Excess capacity limits manufacturers from being cost competitive and sustaining a viable design engineering cadre. The U.S. currently has three full-capability fuze design manufacturing suppliers. The fuze prime contractors are aggressively managing several defense-unique sub-tier component areas, such as electronic energy devices (e.g., bellows actuators), liquid and thermal reserve batteries, and certain obsolete electronic components to ensure their ability to design and produce fuzes in the future.

### Long-Term Challenges

#### Sustaining Design and Engineering Industrial Capabilities

Most current missile development activity consists of modifications to existing missile systems, such as the AIM-9X Block II, PAC 3 Missile System Enhancement (MSE), Advanced Anti-Radiation Guided Missile, and Standard Missile-6 (SM-6). Most of the research and development funding in the munitions and missile sector is associated with legacy program upgrades or modifications, which limit competitive opportunities. The limited number of new missile development programs inhibits the Department's ability to fully exercise the industrial capabilities necessary—from design concept, system development, and production—to meet current and future national security needs. The Long-Range Anti-Ship Missile (LRASM) and the Joint Air-to-Ground Missile (JAGM) are the only “new” missile development programs. However, these too follow the same model. After being restructured as a technology development program, the JAGM program now reflects a front-end modernization for the Hellfire missile. While LRASM leverages a DARPA demonstration project to integrate significant modification to legacy JASSM-ER, it does not rise to the level of a major new program starting from basic technology development.

The Navy is conducting a Capabilities Based Assessment for a follow-on to the Tactical Tomahawk Cruise Missile program and is updating an Analysis of Alternatives to inform a potential follow-on to LRASM (Navy Offensive Anti-Surface Warfare (OASuW)/Increment II). Both programs may be combined into a single Next Generation Strike Capability development program. The Air Force is studying options for follow-on to the Air-Launch Cruise Missile in support of their next generation bomber program. Additionally, ship defense missiles are migrating to active seeker capability, leveraging a common guidance section architecture from the Advanced Medium-Range Air-to-Air Missile (AMRAAM) C-7 to SM-6 Block 1 and Evolved SeaSparrow Missile (ESSM) Block 2. This family of missiles approach helps to mitigate the lower production quantities and leverages previous developments to reduce cost and efficiently utilize the missile design engineering capabilities.

An indication of the concern for strategic missile design engineering capabilities can be seen as the newest DoD strategic missile in the U.S. inventory, the Trident II (D5) missile, began its development in 1978. The Department remains concerned that the design engineering capabilities needed for tactical and nuclear weapon systems may not be readily available should the sector atrophy in the absence of a long-term demand signal. Table 5.5.5 provides a sampling of U.S. missile programs, their dates of development, and their current program variants.

Table 5.5.5

<b>DoD Missile Program Updates</b>			
<b>Missile Program</b>	<b>Development Started</b>	<b>Production or Delivery Started</b>	<b>Current Variant</b>
<b>AIM-9 Sidewinder</b>	1946	1953	AIM-9X
<b>AMRAAM</b>	1979	1988	AIM-120D
<b>Hellfire</b>	1974	1982	AGM-114R
<b>TOW</b>	1963	1968	TOW-2B
<b>Patriot</b>	1969	1981	PAC-3 MSE
<b>Standard Missile</b>	1963	1967	SM-6
<b>Trident II (D5)</b>	1978	1987	D5
<b>Minuteman III</b>	1964	1968	LGM-30G
<b>Tomahawk</b>	1970's	1983	Block IV
<b>JASSM</b>	1995	2001	JASSM-ER

A contraction in the munitions and missile development and procurement market has led to a thinning of expertise in defense-unique technologies in both the contractor and federal government workforces. Declining munitions and missiles research and development funding, coupled with limited competitive opportunities projected in the near-term for new munitions and missile systems, may make it difficult for the missile sector industry to attract and retain a workforce with the industrial capabilities to design, develop, and produce future missile systems that will meet national security requirements.

### Critical Issues

MIBP also collaborated with the OSD-chartered Critical Energetics Materials Working Group (CEMWG) to assess missile energetic materials. Many of these materials have single or sole source suppliers, many of which are foreign suppliers. Examples of domestic and foreign source supplier issues are highlighted below, and various mitigation efforts are discussed in the next section:

- *Hydroxly-terminated Polybutadiene (HTPB)*: HTPB is a polymer which is a key component in a majority of DoD missile systems. The current domestic sole source supplier of HTPB for propulsion applications is Total, a French company. There have

been a number of deficiencies in the material quality and repeatability identified by users, including variability and inconsistency from lot-to-lot, which has resulted in the material being unusable in certain missile systems. Therefore, in addition to the risk from a sole source, foreign owned supplier, there is risk of unavailability of this material for key DoD weapons systems.

- *Ammonium Perchlorate (AP)*: The DoD must find a long-term solution to mitigate the high cost and schedule risk to our missile programs resulting from the fragility of our sole domestic supplier for AP. Numerous studies and reports to Congress have identified the Department's this supplier, American Pacific (AMPAC), as a critical sub-tier supplier. AMPAC produced AP is used in virtually all of the DoD's missile programs. However, due to decreasing demand, AMPAC is currently operating at 10 to 15 percent of facility capacity, resulting in large overhead expenses distributed among a small volume of customers. To date there has been an order of magnitude increase to the price per pound of AP, and projections are for this to continue to increase as demand decreases.
- *Butanetriol (BT)*: The Department has been dependent on a foreign source for BT since 2008. Butanetriol, identified on the U.S. Munitions List (USML), is a chemical precursor needed for production of butanetriol trinitrate (BTTN), a nitrate ester/plasticizer (part of the binder) used in the production of SRMs for the Army's Hellfire, TOW-2, Griffin, and Javelin missile systems.
- *Triaminotrinitrobenzene (TATB)*: TATB is one of the least sensitive explosive materials known. This material is predominantly used in PBXN-7 and PBXW-14 for fuze applications. TATB had not been produced since 2006. The Department awarded Facilitization contracts to establish a new domestic source of TATB in 2011. The TATB plant design completed in 2013 and leverages existing infrastructure. Process prove-out, completion of consecutive specification compliant production runs and formulated production scale batches of PBXN-7/PBXW-14 have been completed. TATB and PBXN-7 have been qualified. The data package for the qualification PBXW-14 has been submitted to the Naval Surface Warfare Center, Indian Head Explosive Ordnance Disposal Technology Division for approval. The Defense Logistics Agency (DLA) has begun to stockpile TATB, PBXN-7 and PBXW-14.
- *Antimony Sulfide*: Antimony sulfide is a component of energetic compositions used in percussion primers and several fuze/detonator ignition trains that support over 200 DoD munitions. It is also an industrial commodity material used commercially to manufacture flame retardant plastics and textiles. Antimony sulfide is refined from stibnite ore that is mined underground. Large deposits of stibnite ore are rare in the earth's crust, and there are no known mines producing acceptable grade ore under United States or NATO partner control. China is the largest producer of antimony sulfide and controls its availability on the world market.

## Mitigation Efforts

During 2014, MIBP led activities to develop, plan, and execute seven IBAS projects intended to mitigate missile sector issues.

### Lifelines and Safe Harbors – Preserving Unique Capabilities

- *Thermal Batteries:* The decline in missile production has made the industrial base for thermal batteries very fragile. Production is falling below minimum sustaining rates. IBAS has initiated three projects for thermal battery technical improvements in battery materials and shelf life that will lower minimum sustaining rates: improved material composition that will provide additional domestic suppliers, characterization of Thermal Battery shelf-life model to enhance production quality and sustainment (reducing costs and industrial base burden), and improved thin film production to broaden and improve the market.

### Design Teams – Preserving Critical Skills

- *Advanced Solid Rocket Propulsion:* This IBAS project focused on supporting and maintaining a design team with special talents for developing weapon systems applications using solid rocket propulsion. This project resulted in a new Solid Diverter and Attitude Control System (SDACS) which can be used in future missile interceptor missions with advanced kill vehicle thrusters for high precision and long duration missions. This project enhanced the DACS capability in the U.S. specifically cited as an industrial base concern by Congress.
- *Fuzes:* Because of the decline in missile production, fuzes are experiencing a decline in production, making the industrial base very fragile. Without intervention, loss of industry design and production expertise is expected for ESAD-based fuzes. ESADs are most commonly used in missile fuzing, but have applicability to some of the Department's most critical gun fired and air delivered munitions as well. To improve the industrial base capability, IBAS is funding ESAD design projects for cost reduction and commonality across multiple missile and munition end-products. Phase I was initiated by contracting with three different suppliers to exercise their engineering capability, including the use of sub-tier suppliers and component technology, to develop lower cost, common architecture ESAD designs. These three suppliers form the critical core of the U.S. Industrial Base for fuzes overall. Phase II is planned for award in FY 2017. In this phase the work from Phase I will then be applied against a post Milestone C munition which can benefit the most from an upgraded fuze capability.

### Industrial Base Supply, Expansion & Competition – Expanding Reliable Resources

- *HTPB:* The Army has a Phase II SBIR project to establish a second source for this material. Both the Army and the Navy are pursuing a Phase III.



- *AP*: MIBP initiated a study with support from the Army and Navy to address this critical need. The objective of the study is to explore mitigation alternatives that have the potential to reduce the ammonium perchlorate cost and supply risks for DoD. This should, at a minimum, include identifying approaches to reduce the capacity in the existing facility, and analyzing cost and schedule for development of a new right-sized facility. Reducing the re-qualification cost burden for DoD weapons systems that experience an ingredient change must also be addressed.
- *Butanetrio (BT)*: The U.S. Army qualified a new domestic source for BT in FY 2013. In FY 2014, the Department used the IBAS program to fund the transition of the process for manufacturing BT from a developmental “Pilot Line” to a production-scale capability with the capacity to meet the Department’s program requirements. Qualification of BTTN with the new BT, and then missile systems that will use the new BTTN will follow. This project will ensure the sustainment of this capability across many DoD programs including the HELLFIRE, JAGM, TOW, Javelin, Griffin, AIM-9x, AEGIS and Chaparral weapon systems.
- *Low Energy Expanding Foil Initiator*: This IBAS project established a second reliable source for an at-risk producer of detonators used by 12 key DoD weapons systems.

While many industrial sectors that support our national security requirements are supported by the commercial markets, the munitions and missile industrial sector is mostly defense-unique. Given the constrained DoD budget environment, investments in missile research and development and procurement may be more challenged even further. The munitions and missiles industrial sector already faces a number of challenges, which generally fall into two broad categories: (1) sustaining design and engineering teams and (2) sustaining sub-tier suppliers. Most of the R&D funding in the missile sector is associated with legacy program upgrades or modifications, which limits competitive opportunities and our ability to fully exercise the industrial capabilities necessary in the missile industrial base to meet current and future national security needs. The Department is concerned with the ability of our munitions and missile prime contractors to sustain critical sub-tier suppliers. The munitions and missile industrial sector is routinely impacted by significant shifts in DoD demand as a result of various factors, but mostly the initiation or drawdown of conflicts.

## 5.6 Shipbuilding Sector Industrial Summary

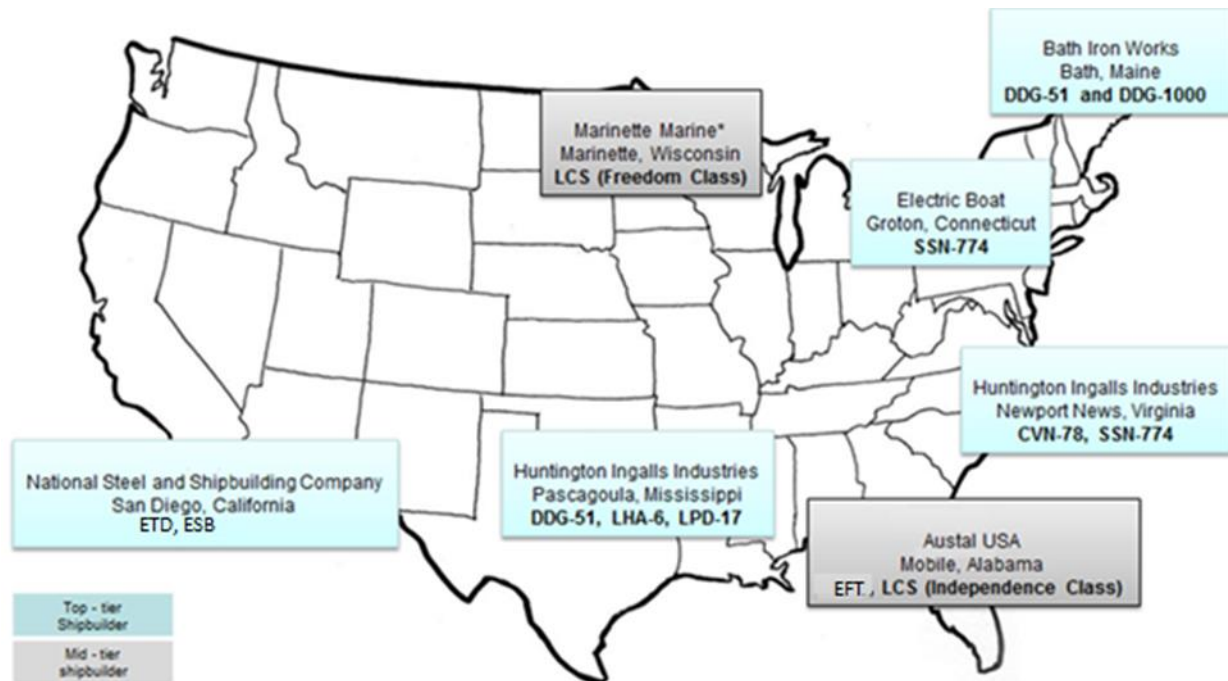
### Industry overview

The shipbuilding Defense Industrial Base is comprised of primarily seven shipyards owned by four companies, two mid-sized shipyards, and other shipyards which concentrate on commercial ships but will periodically enter and exit the naval market. The seven shipyards which almost exclusively construct naval ships are listed below and identified in Figure 5.6.1.

- General Dynamics Marine Systems, Bath Iron Works (GD-BIW) – Bath, Maine
- General Dynamics Marine Systems, Electric Boat (GD-EB) – Groton, Connecticut

- General Dynamics Marine Systems, NASSCO (GD-NASSCO) – San Diego, California
- Huntington Ingalls Industries, Newport News Shipbuilding (HII-NNS) – Newport News, Virginia
- Huntington Ingalls Industries, Ingalls Shipbuilding (HII-Ingalls) – Pascagoula, Mississippi
- Marinette Marine Corporation (MMC) – Marinette, Wisconsin
- Austal USA (Austal) – Mobile, Alabama

Figure 5.6.1 U.S. Shipyards constructing ships for the Department of Navy



Source: Industry Sector Economic Assessment – Naval Shipbuilding (Defense Contract Management Agency, 2014)

The DIB for shipbuilding is segmented by ship type: aircraft carriers, submarines, surface combatants, amphibious warfare, combat logistics force, and command and support vessels. A summary of the current shipyards product lines for the U.S. Navy is provided in Table 5.6.2.

Table 5.6.2: Shipbuilding Sector Navy Product Lines

Programs Prime Contractor	Shipyard	Type of Ships	Programs
General Dynamics	Bath Iron Works	Surface Combatants	Arleigh Burke Class Guided Missile Destroyer (DDG 51 Class)
			Zumwalt Class Destroyer (DDG 1000)
	Electric Boat	Submarines	Virginia Class Submarines (SSN)
	NASSCO	Expeditionary Support Ships	Expeditionary Transfer Dock (ESD, formerly MLP)
			Expeditionary Sea Base (ESB, formerly AFSB)
Huntington Ingalls	Newport News	Aircraft Carrier	Gerald R. Ford Class Nuclear Aircraft Carrier (CVN )
		Submarines	Virginia Class Submarines (SSN)
	Ingalls	Surface Combatant	Arleigh Burke Class Guided Missile Destroyer (DDG 51)
		Amphibious Warfare	America Class Amphibious Assault (LHA)
		Amphibious Warfare	San Antonio Class Amphibious Transport Dock (LPD)
		Surface Combatant	National Security Cutters (WMSL)
Lockheed Martin <sup>21</sup> /Fincantieri	Marinette Marine	Surface Combatant	Littoral Combat Ships (LCS)
Austal USA	Austal Mobile	Surface Combatant Expeditionary Support Ship	Littoral Combat Ships (LCS) Expeditionary Fast Transport (EPF, formerly JHSV)

In addition to the aforementioned shipyards, two mid-sized yards, Dakota Creek Industries and VT Halter Marine, are building oceanographic research ship (AGOR 28) and a oceanographic surveying ship (AGC 66) respectively.

Per the Future Years Defense Program, the Navy has begun efforts to replace five aging ship classes. Two new amphibious programs [LHA 8 and LX-(R)], the fleet replenishment oiler program [T-AO(X)], the fleet ocean tug program [T-ATS, formerly T-ATF(X)], and the Ohio Replacement (OR) program, will provide both design and production workload for the winning shipyards. Table 5.6.3 depicts the expected lead ship contract award years.

<sup>21</sup> Lockheed Martin is the prime contractor for LCS ships, however the ships are built at the Marinette Marine shipyard.

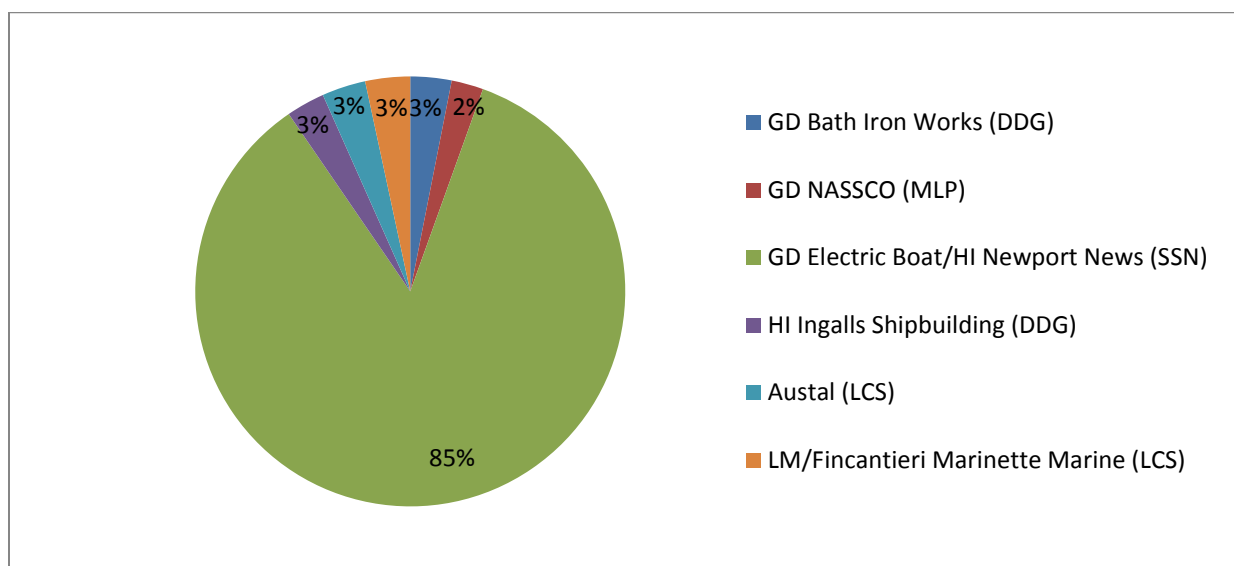
Table 5.6.3: Future Navy Programs (based on FY 2016 procurement plan)

Program	Type of Ships	Expected Contract Award Year
Fleet Replenishment Oiler (T-AO(X))	Combat Logistics Force	2016
Fleet Ocean Tug Replacement (T-ATS)	Fleet Support Ship	2017
Landing Helicopter Dock (LHA 8)	Amphibious Warfare	2017
Dock Landing Ship (LSD) 41/49 Class Replacement (LX-(R))	Amphibious Warfare	2020
Ohio Replacement Program (OR)	Submarines	2021

### Budget Considerations

The U.S. shipbuilding industrial base depends on DoD business to sustain critical design and manufacturing skills, as well as to maintain their current infrastructure. Figure 5.6.4 provides the percentage of participation of the shipyards in the contracts awarded during 2014. GD-EB and HII NNS were reported together since they are building the Virginia Class submarines through a partnership arrangement.<sup>22</sup>

Figure 5.6.4 Percent of Navy Contract Awards by Shipyard in 2014



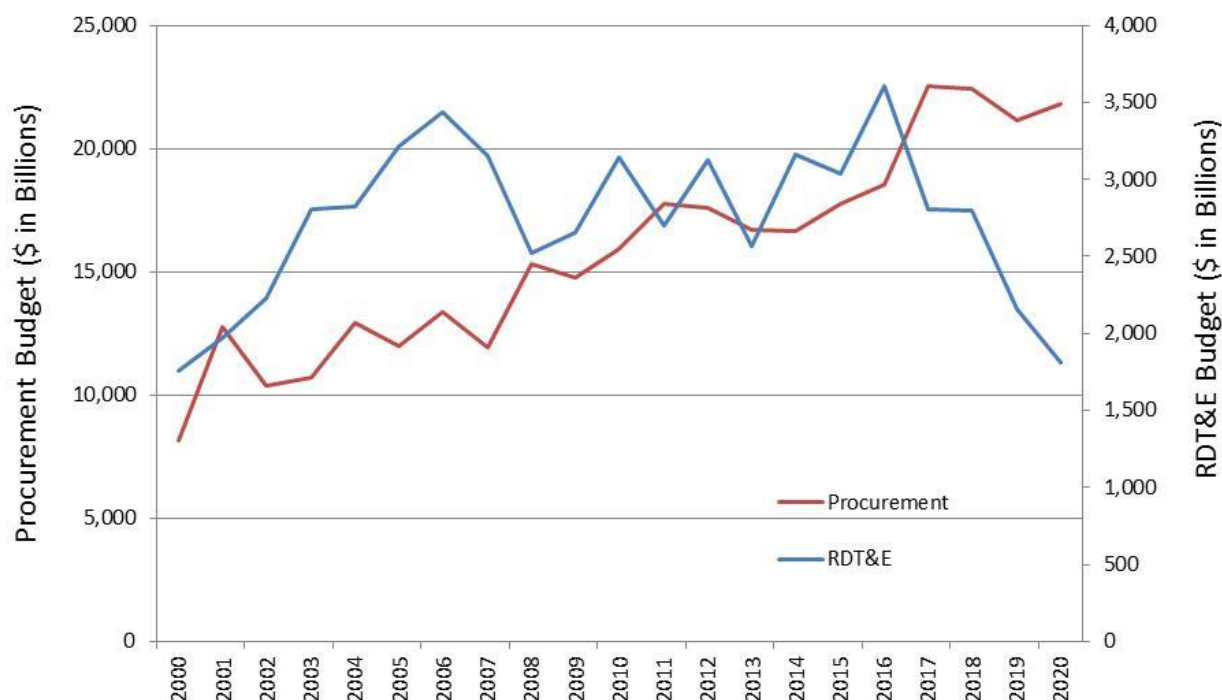
Source: Defense Research Data Warehouse

In FY14, DoD's shipbuilding procurement funds stayed relatively stable when compared to FY13. The U.S. Navy was able to manage the effects of the 2013 sequestration due to reprogramming actions that allow execution of priority programs to meet the Defense Strategic Guidance and by deferring costs to future years. With the Bipartisan Budget Act (BBA) of 2013,

<sup>22</sup> Data Source: <http://www.shipbuildinghistory.com/today/statistics/contracts2014.htm>

the Navy avoided the need to apply funding reductions across all programs in FY14 and FY15. Funds for RDT&E increased by 23% in 2014 due to development contracts for the OR and LHA programs. Figure 5.6.5 illustrates DoD's budget trends in the shipbuilding sector.

Figure 5.6.5 DoD's Budget Trends in Shipbuilding (Procurement and RDT&E funds based on 2016 Presidential Budget)



Source: Defense Research Data Warehouse

### At-risk areas

The Navy's Shipbuilding Industrial Base Report of March 2015 identified the Amphibious and Auxiliary Ships industrial base to be the most at risk area if funding levels were reduced. Subsequently, the U.S. Navy developed an acquisition strategy for the LHA 8, T-AO (X), and LX(R) programs that will sustain competition by stabilizing the workload for the shipyards from 2016 to 2024. However, additional budget cuts may put the acquisition strategy at risk or delay its execution.

### Critical Issues

The potential impact of additional budget cuts to existing contracts and to future acquisition programs continues to be a concern. Given the dependence of the shipbuilding sector on defense contracts to maintain a skilled workforce and infrastructure, reductions in quantity and/or fleet composition may threaten the viability of some of the shipyards and their suppliers and therefore reduce potential benefits achieved from competition in this market.

## Long Term Challenge

The long term challenge for the U.S. Navy is to find the way to balance the budget to fund the Ohio Replacement program without sacrificing other shipbuilding programs. The Ohio Replacement program is the number one priority for the U.S. Navy and part of the national defense strategy to modernize the nuclear weapon systems.

## Mitigation Efforts

The Department of Navy recognizes the importance of maintaining a competitive environment to achieve affordable programs. The Navy, through acquisition strategies, is promoting dual sourcing options to drive innovation and reduce costs. In order to maintain stability in the sector, the Navy is involving the shipyards early in the design process, supporting shipbuilding capabilities preservation agreements, and promoting block buys and multiyear procurement strategies.

The U.S. Navy has considered their need to balance force structure, readiness, and capability to meet national security commitments in their President's Budget submissions. Construction plans have been developed to minimize impacts to the industrial base where possible, in order to avoid future increases in cost above inflation, or potential permanent losses to this national industrial capability. Additionally, the combination of new Navy procurement and maintenance programs, along with commercial ship construction, will help strengthen and support the shipbuilding sector.

The U.S. Navy's Shipbuilding Industrial Base Report to Congress indicates that the Service is committed to the maximum extent possible to preserve ship construction if sequestration returns in the future years.

## **5.7 Space Sector Industrial Summary**

### Industry overview

The overall health of the U.S. space industrial base is good. The space industry continues to grow, though U.S. growth has slowed from previous years. The sector is primarily driven by the commercial market and includes: satellites, launch services, ground systems, satellite components and subsystems, networks, engineering services, payloads, propulsion, and electronics. This commercial focus has many benefits for the DoD in that it can take advantage of commercial technology advancement, but it also can impose additional sources of vulnerability for a number of reasons:

- As the space industry globalizes, companies continue to outsource certain capabilities that are produced more economically abroad;
- Budget declines or program cancellations force companies to reduce R&D spending, eliminate product lines, or go bankrupt;

- Industry shifts its product focus away from defense to commercial products where it can obtain better returns on invested capital; and
- Environmental restrictions may prohibit production.

Therefore, the Department must remain vigilant to maintain critical capabilities that are specialized for military applications. This is particularly true for DoD space applications, which typically require cutting-edge technology and stringent requirements but often have very low production quantities when compared with commercial products.

### Budget considerations

According to the Space Foundation's annual Space Report, the global space economy grew by 9 percent in 2014 to \$330 Billion<sup>23</sup> (a new record). The vast majority of this growth was in the commercial sector, representing 76 percent of the space economy. Overall government investment rose by 7.3 percent, with U.S. growth at only 1 percent. The U.S. space budget remained the largest in the world at \$43 Billion, although its global dominance is rapidly eroding as other countries are racing to catch up. As a percentage of global government spending, the United States was 74 percent in 2010, 61 percent in 2012, and 54 percent in 2014—a 20 percent reduction in just five years.

The global satellite industry is a subset of the \$330 Billion global space industry. In 2014, there were 1,261 satellites operated by more than 57 countries. More than half of the satellites are communications satellites and more than a third are commercial communications satellites. Global satellite industry revenues grew at a rate of 4 percent in 2014, surpassing the 2013 growth rate of 3 percent. These revenues can be further divided into multiple sectors: Services, Manufacturing, Launch, and Ground Equipment. At \$123 Billion, Services account for 61 percent of industry revenues. Services revenues grew by 4 percent, primarily due to growth in satellite television. Satellite manufacturing revenues grew by just 1 percent despite almost doubling the number of satellites launched (from 107 in 2013 to 208 in 2014). This included 130 CubeSats which represented less than 1 percent of the total revenues generated. U.S. satellite manufacturers' revenues decreased by 9 percent, with U.S. firms earning 62 percent of global satellite manufacturing revenues. Additionally, in 2014, U.S. industry won only 13 of the 22 commercial GEO satellite orders (this represents 59 percent of sales, down from peak sales of approximately 65 percent in 2012 and 2013). The satellite launch industry saw a 9 percent growth rate in 2014, stemming from more European and U.S. launches of commercial satellites compared to 2013. The U.S. market share for this sector was 41 percent, down from 45 percent in 2013. Future indicators for commercial satellite launch showed a decrease in launch orders from 32 in 2013 to 22 in 2014, however 50 percent of those orders were won by U.S. companies (up 83 percent compared to 2013), with Russian launch providers experiencing a dramatic drop due reliability issues and Ukraine conflict.

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<sup>23</sup>[https://www.spacefoundation.org/sites/default/files/downloads/The\\_Space\\_Report\\_2015\\_Overview\\_TOC\\_Exhibits.pdf](https://www.spacefoundation.org/sites/default/files/downloads/The_Space_Report_2015_Overview_TOC_Exhibits.pdf)

### At-risk areas

DoD and USG-wide studies and analyses have identified at-risk capabilities, fragile suppliers and stress in the lower tiers of the Space Industrial Base. The DoD space industrial base (SIB) remains a niche market with very specialized and capital-intensive capabilities that are not efficiently managed through individual program investment. Continued declines in defense funding and sequestration could further endanger the critical capabilities needed to satisfy current and future program requirements. For example, as part of the Department of Commerce (DoC)-led Space Deep Dive (SDD) study, over 10% of the 3,585 space suppliers surveyed (438 vendors) indicated a potential loss of viability or solvency as a result of sudden decreases in space-related demand.

Space systems provide an emergent capability and strategic advantage to U.S. forces; the Secretary of Defense has identified space capabilities as a strategic budget priority. MIBP-led Space Sector FaCs Assessments, the DoC-led SDD study and the Space Industrial Base Council (SIBC) Critical Technology Working Group (CTWG) have completed detailed assessments of the most critical space industrial base capabilities and fragile suppliers. As part of the DoC SDD survey, about 40% of the 3,585 space suppliers surveyed were identified as being at elevated or high financial risk. That percentage increases to as much as 60% when you look at suppliers that support space unique activities such as space related R&D, propulsion, spacecraft and launch vehicles. Over 130 critical capabilities and approximately 500 suppliers were assessed as part of the Space Sector FaC assessment, resulting in a stratification of capabilities and vendors where proactive risk mitigation is needed. In addition, security of supply and the need for trusted, domestic sources for space-qualified components continues to be a significant challenge.

### Current Capabilities at Risk

Based on current assessments of essential military space capabilities, measuring the degree to which each capability was fragile (i.e. supplier viability risk) and critical (important to DoD programs), the top 15 most-at-risk capabilities were chosen. The CTWG then conducted more extensive analysis using interagency Technical Teams to determine if a capability was seriously at risk. Of the 15 capabilities studied, seven were identified as requiring near-term mitigation:

- Radiation-hardened electronics
- Radiation test facilities
- Carbon fiber
- Infrared detectors
- Electric propulsion
- Aerospace-grade rayon
- Reaction wheels

### Long-Term Challenges

Many current programs will soon or have already transitioned to a production-like cadence (block buys of satellites on SBIRS, AEHF, WGS, GPS III), which will put key satellite



design teams/skills at risk. Satellites are also lasting longer on orbit, which will likely delay New Starts in some mission areas. DoD Space Sector RDT&E funding, in PBY15, has decreased by 39.9% between the FY10PB and the FY15PB, and DoD Space Sector Total Investment funding, in PBY15, has decreased by 29.5% between the FY10PB and the FY15PB (includes MIP, but not NIP funding).<sup>24</sup> All of these factors are creating a “demand trough” that is starving the lower tiers of the Space Industrial Base and threatening the loss of essential space capabilities and critical design skills.

### Mitigation Efforts

A DMAG decision in December 2013 approved the request from the USD(AT&L) and other DMAG principals to establish a “Space Industrial Base Capability Program.” This program will fund a systematic, sector-wide, interagency approach to identify, assess and mitigate risk in the space industrial base. In addition, this effort will fund targeted investments to: 1) maintain critical space industrial base capabilities, 2) develop manufacturing capability and qualify products and components for future insertion into programs of record, and 3) preserve decision trade space for the department as it satisfies current and future requirements.

Following the 2013 DMAG decision to establish a “Space Industrial Base Capability Program,” the 2014 DMAG approved \$28M to sustain critical space technology development and critical elements of the space industrial base. This provided initial funding, out of an estimated \$322M required, for 10 technology areas identified as highest priority based on conducted FaC assessments of the Space industrial base. The 2014 DMAG also directed the DoD Executive Agent for Space with USD(AT&L), in coordination with current funding stakeholders, Air Force, MDA, and NRO to: 1) revise and renew the National Security Space Industrial Base Risk Management Program Memorandum of Agreement; and 2) assess current and proposed National Security Space industrial base assessments and develop a multi-agency set of priorities and roadmap, including programmatic transition points and provide a recommended set of priorities, recommendations for FY 2015 and/or FY 2016 reprogramming, and a roadmap to the Defense Space Council by 26 Jun 2015.

With the declining DoD Space Funding seen in the PB08 through PB15, there was a major need for proactive, integrated assessment and mitigation efforts.<sup>25</sup> In order to sustain sub-tier providers of critical space capabilities the CTWG used previously conducted assessments to make investments in the following areas; Payload, Propulsion, Power, Altitude Determination & Control, and the parts and materials that impact them. The main goal was to establish a systematic, strategic approach to proactive assessments and mitigation of space enterprise IB risk. The demand for the projects relied upon creating a trusted domestic supply or domesticating manufacturing capabilities that were eroding. The multi-agency assessments identified 11 high risk IB capabilities and funding/investments were made producing the following results in support of advanced technology capability and industrial base sustainment initiatives.

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<sup>24</sup> Defense Resource Data Warehouse

<sup>25</sup> Defense Resource Data Warehouse

- Power focused projects focused on: Power systems, Batteries, Photovoltaic solar arrays, Solar cells, Battery Cells (Li-ion, NiH), Electrolytes (Li-ion). After completion of the Li-Ion Batteries project there is a full domestic production line which is currently going through the qualification process. For the Cellophane for Silver-Zinc Batteries there is current testing and collaboration with manufacturer to extend shelf life beyond the six months warranty period. With completion of the Solar Cells Project, we have assured the viability and reinvigorated the competitiveness of the sole domestic supplier.
- Payload focused projects: Travelling wave tube amplifiers (TWTA), Traveling wave tubes, Imagers, Readout integrated circuits, Germanium. The completion of the TWTA project enabled domestic production with twice the power and bandwidth of foreign suppliers. Readout Integrated Circuits (ROIC) project produced two trusted domestic ROIC foundries for NSS requirements.
- Altitude Determination and Control focused projects: Telemetry, tracking & command, Guidance & navigation, Star Trackers, and visible light sensors. For the CZT IR Detectors project potential domestic merchant suppliers were identified and contract was to be awarded in FY15. Development of domestic capability to transition Star Tracker design from Charged Coupled Device (CCD) to Complementary Metal-Oxide Semiconductor (CMOS) technology was developed and a contract is to be awarded in FY15.

In addition to the CTWG programs related to the Space Vehicle, there are also several efforts related to Launch Vehicles:

- Power focused projects: Batteries, Battery Cells (Li-ion, NiH), Electrolytes (Li-ion)
- Propulsion focused projects: Propulsion Systems (Liquid Rocket Engines), Heat exchangers and Combustion chambers, Engine valves and injectors. In the case of the Liquid Rocket Engines project development of domestic capability for precision fabrication methods to produce rocket components was developed.

The CTWG recognized that effective space IB risk mitigation is best shared among enterprise partners where you can target investments at the most important elements and through a shared effort maximize efficiency of investments. Out year planning and funding for the Current Capabilities at Risk identified above is based on a coordinated strategy between OSD, AF, NRO, and MDA to maximize application of funding and reduce program specific duplication of efforts planned for execution from FY16-FY21.

## **6. Defense Mergers and Acquisitions**

Robust, credible competition is vital to providing the Department with high-quality, affordable, and innovative products. It is the Department's policy to oppose business combinations that reduce or eliminate competition and are not in its ultimate best interest. The Department is mindful of the past loss of peer-to-peer competition at the prime level resulting from significant industry consolidations over the past twenty years. Increasingly, the Department

finds itself evaluating proposed mergers, acquisitions, and teaming arrangements that create horizontal capability overlaps; and potentially problematic vertical supply arrangements.

The Department examines potential transactions on a case-by-case basis. During the course of a review (other than under CFIUS), the Department considers a transaction's potential benefits compared to the potential harm caused by a transaction's reduction of competition, among other factors.

DoD reviews several types of business combinations involving defense suppliers:

- Proposed mergers or acquisitions filed under the Hart-Scott-Rodino Antitrust Improvement Act of 1976 (generally, transactions valued at more than \$75.9M in 2014);
- Other collaborations among competitors (joint ventures, mergers and acquisitions) of special interest to the Department that do not meet the Hart-Scott-Rodino Act filing threshold; and
- Proposed acquisitions of U.S. defense-related firms by non-U.S. firms for which filings have been made pursuant to the Exon-Florio Amendment to the Omnibus Trade and Competitiveness Act of 1988, as amended by the Foreign Investment and National Security Act of 2007, Public Law 110-49.

The first two review types described are conducted under Major Defense Supplier merger and acquisition (M&A) reviews pursuant to DoD Directive 5000.62.

## **6.1 Major Defense Supplier Merger and Acquisition Reviews**

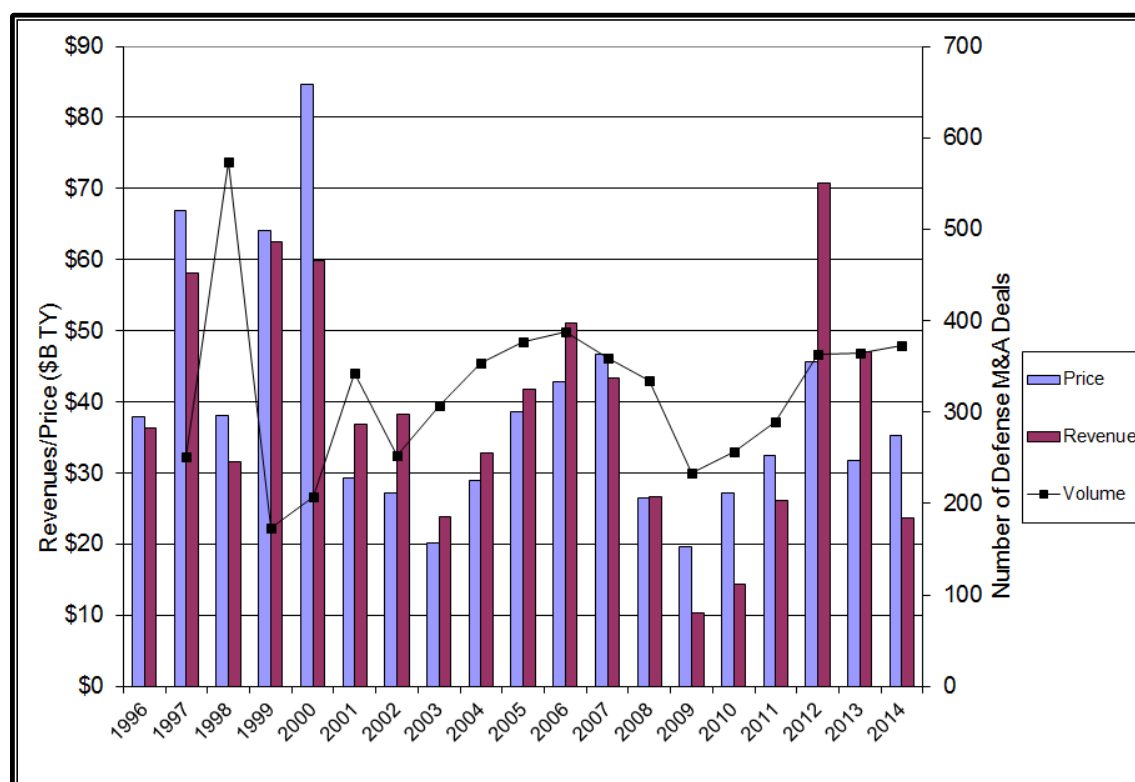
The Federal Trade Commission and the Department of Justice (the "Antitrust Agencies") have the statutory responsibility for determining the likely effects of a defense industry merger on the performance and dynamics of a particular market, and whether a proposed merger should be challenged on the grounds that it may violate antitrust laws. As the primary customer affected by defense business combinations, DoD's views are particularly significant because of its special insight into a proposed merger's impact on innovation, competition, national security, and the defense industrial base. Accordingly, the Department actively works with the Antitrust Agencies, but also can independently address issues where appropriate.

Transaction reviews are structured to identify impacts on national security and on defense industrial capabilities. They evaluate the potential for loss of competition for current and future DoD programs, contracts and subcontracts, and for future technologies of interest to the Department. In addition, the reviews address any other factors resulting from the proposed combination that may adversely affect the satisfactory completion of current or future DoD programs or operations. The policies and responsibilities for assessing major Defense supplier M&A reviews are identified in DoD Directive 5000.62. While these reviews can include transactions that are also evaluated in the Committee on Foreign Investments in the United States (CFIUS) review process, the issues considered are distinct.

### 6.1.1 2014 Major Defense Supplier M&A Activity

In 2014, the Department completed 20 reviews of significant transactions out of the approximately 400 defense-related mergers and acquisitions over the course of the year. The table below highlights the aggregate number and value of these transactions as reported by InfoBASE. While the total revenue of the transactions has fallen since the 2012 high (influenced by United Technologies' \$18.4B acquisition of Goodrich), the number of transactions has remained steady.

**Figure 6.1.1 Defense-related M&A Transactions**



Source: Infobase Defense Merger & Acquisition data on publicly announced deals. Includes foreign-only deals and failed deals. (Defense Merger and Acquisition Transactions 1996-2014)

The year was dominated by several noteworthy transactions, including:

#### Engility-TASC:

The Department's assessment of Engility's \$1.1B acquisition of TASC found that the companies rarely competed in the same subsets of the service market. TASC's strengths lie in the intelligence community where it is known as a high-cost, highly-technical systems engineering and professional services provider to intelligence, cybersecurity, and space systems customers – where Engility is not a primary competitor.

### Exelis' spinoff of Vectrus:

At the time of the Department's review of Exelis' spinoff of Vectrus (ITT Mission Systems), the spinoff company was expected to receive declining annual revenue to and narrowing operating margins. Beyond 2014, the revenue profile was expected to face a few key program terminations and re-compete with an associated significant decline in revenue due to lower demand as a result of smaller U.S. presence in Afghanistan.

### Textron-Beech Holdings:

The Department's review of Textron's \$1.4B acquisition of Beechcraft and Hawker aircraft businesses found that the Textron's Cessna aircraft was not a primary competitor to Beechcraft for the Department's Fixed Wing Utility Aircraft, Airlift/Transport, and Special Mission turboprop aircraft procurement opportunities due to the lack of Cessna aircraft's cabin oxygenation. The review found no jet powered product overlaps, as Beech had previously discontinued its jet manufacturing business.

### Orbital-ATK:

The joint DoD/DoJ review of the \$4.5B Orbital-ATK "Morris Trust" merger included over 100 interviews over a nine-month period. The review focused on potential vertical integration foreclosure harm involving solid rocket motors for small/medium launch vehicles and suborbital missile targets. Other review areas included:

- horizontal competition for satellites;
- vertical integration involving solid rocket motors for ballistic missile interceptors, conventional prompt global strike, and next-generation ICBMs, and
- vertical integration involving satellite components including propellant and pressurant tanks, deployable structures, thermally stable structures, and satellite heat pipes.

The assessment concluded the Orbital-ATK transaction was not likely to foreclose competitors or harm competition for launch vehicles and suborbital missile targets. Similarly, the transaction was found not likely to result in reduced satellite competition or foreclose competitors or harm competition in the remaining review areas.

## **6.2 Committee on Foreign Investment in the United States**

Section 721 of the DPA (50 U.S.C. App. Section 2170 et seq.) authorizes the President to suspend or block foreign acquisitions, mergers, or takeovers of U.S.-located firms if the transactions pose credible threats to national security that cannot be resolved through other provisions of law. Initially enacted as the Exon-Florio Amendment to the Omnibus Trade and Competitiveness Act of 1988, Section 721 was revised by the Foreign Investment and National Security Act of 2007, Public Law 100-49 (FISIA). Under FISIA, national security reviews of foreign acquisitions, mergers, and takeovers of defense-related U.S. firms under Section 721 are the responsibility of the interagency CFIUS, chaired by the Department of the Treasury.

DoD is a member of CFIUS and MIBP is the DoD lead for the CFIUS program. As a CFIUS member, the Department evaluates the national security aspects of proposed foreign acquisitions of U.S. defense contractors and other U.S. firms indirectly impacting national defense.

Congress provided the Department independent authority in 1992 (under 10 U.S.C. Section 2537(c)) to determine for each CFIUS case whether the firm being acquired possesses critical defense technology under development or is otherwise important to the defense industrial and technology base. The Defense Intelligence Agency, in conjunction with this 1992 statutory mandate, provides the Department with an assessment of the risks of unauthorized technology transfer and diversion. Under FINSA, the Office of the Director of National Intelligence also prepares a national security threat assessment for CFIUS that evaluates potential threats posed by the acquiring firm and country.

When the Department concludes that a merger, acquisition, or takeover under CFIUS review poses credible threats to national security that cannot be addressed through other provisions of law, it proposes mitigation measures under CFIUS (if these are feasible and adequate to eliminate risks posed by the transaction). If this is not the case, the Department then proposes that CFIUS recommend to the President that he block or unwind the transaction. Given the statutory constraints on public disclosure of case-specific CFIUS information and the lead role that the Treasury Department plays as CFIUS Chair in communication with the Congress, both of which were refined by FINSA, the Department cannot publicly discuss specific reviews or present summary case trends. However, under FINSA, summary CFIUS trend data is provided to the Congress in annual reports by the Treasury Department as the Chair of the Committee.

## **7. Programs and Actions to Sustain Capabilities**

### **7.1 The Defense Production Act**

The Defense Production Act of 1950 (DPA), as amended (50 U.S.C. App., §2061 et seq.), is the primary source of Presidential authorities to expedite supply and expand productive capacity of materials and services needed to promote the national defense. For the purposes of the DPA, “national defense” means programs for military and energy production or construction, military or critical infrastructure assistance to any foreign nation, homeland security, stockpiling, space, and any other directly related activity. “National defense” also includes emergency preparedness activities conducted pursuant to Title VI of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) (42 U.S.C. § 5195 et seq.) and critical infrastructure protection and restoration.

Major DPA provisions include:

- The authority to require acceptance and priority performance of contracts and orders to promote the national defense (DPA section 101);

- The authority to allocate materials, services, and facilities in such manner, upon such conditions, and to such extent as deemed necessary or appropriate to promote the national defense (DPA section 101);
- Various forms of financial incentives and assistance for industry to reduce current or projected shortfalls of resources essential for the national defense; or to create, maintain, protect, expand, or restore domestic industrial base capabilities essential for the national defense (DPA Title III);
- Antitrust protection for voluntary agreements and action plans among business competitors to enable cooperation to plan and coordinate measures to increase the supply of materials and services needed for the national defense (DPA section 708);
- The authority to establish a cadre of persons with recognized expertise for employment in executive positions in the Federal Government in the event of an emergency (DPA section 710(e)); and
- The authority to review certain mergers, acquisitions, and takeovers by or with any foreign person that could result in foreign control of any person engaged in interstate commerce in the United States (DPA section 721).

### **7.1.1 The Defense Production Act Committee**

The DPAC was established by section 722 of the DPA to advise the President on the effective use of the priorities and allocations authorities in support of the national defense. The Administrator of the Federal Emergency Management Agency (FEMA) is designated the Chairperson of the DPAC, in accordance with subsection 722(b)(2) of the DPA. The DPAC is comprised of the Secretary of State, the Secretary of the Treasury, the Secretary of Defense, the Attorney General, the Secretary of the Interior, the Secretary of Agriculture, the Secretary of Commerce, the Secretary of Labor, the Secretary of Health and Human Services, the Secretary of Transportation, the Secretary of Energy, the Secretary of Homeland Security, the Director of National Intelligence, the Director of the Central Intelligence Agency, the Chair of the Council of Economic Advisers, the Administrator of the National Aeronautics and Space Administration, and the Administrator of General Services.

The Director of the Office of Management and Budget and the Director of the Office of Science and Technology Policy may be invited to participate in Committee meetings and activities in an advisory role. The DPAC Chairperson may also invite the heads of other departments and agencies to participate in DPAC meetings, as appropriate.

Most interagency activities to address and coordinate priorities and allocations issues are conducted by working groups composed of representatives from various DPAC Member agencies. The DPAC Principals meet only when such issues cannot be resolved via interagency meetings at a lower level. No unresolved issues that required decisions by the DPAC Principals were identified during 2014.

### **7.1.2 Defense Production Act Title III Program Execution**

The Secretary of the Air Force is the DoD Executive Agent for the DPA Title III Program. The Air Force Title III Program Office located at Wright Patterson AFB, OH provides the technical, financial, and contracting expertise to manage Title III projects from inception through completion. In CY2014, the Title III Program had 34 projects (some with multiple industry partners) underway during the course of the year, and 8 of those projects concluded by the end of the year. At the start of CY2015, 26 domestic firms were under agreement/contract. Pre-award acquisition activities were initiated for an additional 8 projects in 2014, anticipating contract awards in CY2015 or CY2016. Appendix C-1 provides a detailed description of the 2014 projects.

Title III projects in CY2014 include:

- Additive Manufacturing for Liquid Rocket Engines Project
- Advanced Carbon Nanotube (CNT) Volume Production Project
- Advanced CMOS Focal Plane Arrays (FPA) for Visible Sensors for Star Trackers Project
- Advanced Drop-In Biofuel Production Project
- Bio-Synthetic Paraffinic Kerosene (BSPK) Project
- CO2 Absorbent Reactive Plastic Project
- Coal-Based Carbon Foam Project
- Conductive Nano-Materials Scale-Up Initiative Project
- Extremely Large Domestic Expendable & Reusable Structures (ELDERS) Project
- Gallium Nitride Advanced Electronic Warfare Monolithic Microwave Integrated Circuit Producibility Project
- Heavy Forgings Capacity Improvement Project
- High Homogeneity Optical Glass (HHOG) Project
- Integrated Advanced Composite Fiber Placement (IACFP) Project
- Light-Weight Ammunition Project
- Lithium-Ion Battery Production for Military Applications (LIMA) Project
- Lithium Ion Battery Production for Space (LISA) Project
- Low Cost Military GPS Receivers Project
- Non-Aerospace Titanium for Armor and Structures Transformation Project
- Polyhedral Oligomeric Silsesquioxanes (POSS™) Nanotechnology Project
- Radiation-Hardened Cryogenic Readout Integrated Circuits
- Read Out Integrated Circuit Foundry Improvement and Sustainability Project
- Solid Rocket Motors Production Project
- Space Qualified Solar Cell Germanium Substrate Supply Chain Improvement Project
- Thermal Battery Production Project
- Traveling Wave Tube Amplifiers (TWTA) for Space Project
- Tungsten Rhenium Wire Production Sustainment Project
- ALON® and Spinel Optical Ceramics Project



- Gallium Nitride Radar and Electronic Warfare Monolithic Microwave Integrated Circuit Producibility Project
- Military Lens System Fabrication and Assembly Project
- Mini-Refrigerant Compressors for Man-Portable Cooling Project
- Silicon Carbide Powder Production and Ceramic Armor Manufacturing Project
- Small Secure SATCOM Transceiver Project
- Terahertz Spectrometer Project
- Vacuum Induction Melting, Vacuum Arc Remelting Furnace Capacity Project

Funding for individual Title III initiatives is provided by the Joint or Military Department Program Offices of Record, Defense Agencies, or other Federal Agencies as funding offsets for specific Title III efforts. Projects are developed in response to specific Government requirements and associated funding that is provided for these efforts.

## **7.2 DoD Manufacturing Technology Program**

For over 50 years, the DoD Manufacturing Technology (ManTech) Program has demonstrated its value through process technologies that make new products possible, as well as through manufacturing process improvements that focus specifically on defense system affordability challenges. The program provides the crucial links from technology invention to production of defense-critical needs in areas beyond normal investment risks within industry. ManTech ensures technology is affordable and producible, both of which are key to the Department's Better Buying Power initiative and to making sure that U.S. military forces are more agile, deployable, sustainable, lethal, and dominant. While ManTech investments generally translate into initial system affordability improvements or cycle time reduction, investments are also made in new capabilities that provide dividends in system performance or life cycle cost that can far outweigh the initial system delivery costs.

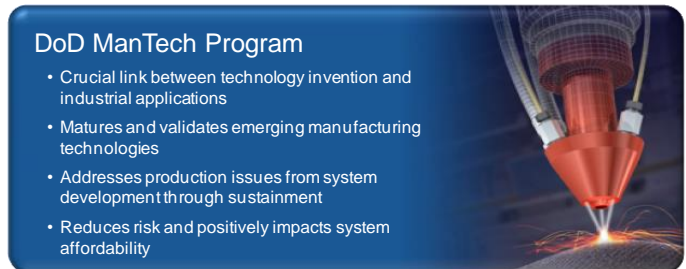
The industrial base is significantly enhanced through the ManTech Program's enabled transition of S&T successes. Specifically, ManTech serves as an important mechanism for technology transition, bringing affordable technologies to acquisition program managers through new manufacturing and production processes and systems, thus bridging the gap between discovery and implementation of new capabilities for the Warfighter. Further, the DoD ManTech Program can contribute important information to MIBP's ongoing industrial base analyses through its operational perspectives of defense manufacturing capabilities, as well as its deepening understanding and insights of technology-based supply chain risks. Conversely, ManTech can be used as an appropriate investment lever for targeted industrial base intervention when necessary to help the Department close newly identified, defense-critical, manufacturing technology related supply chain gaps.

While ManTech is not statutorily structured to address the entirety of defense industrial base challenges, it is a highly versatile R&D investment program that can serve as a key focal point to bring attention and technological resources to bear on the Department's most pressing requirements for affordable modernization and sustainment. The ManTech Program shares an expansive vision with the broader defense manufacturing enterprise; namely, *a responsive, world-class manufacturing capability to affordably and rapidly meet Warfighter needs*

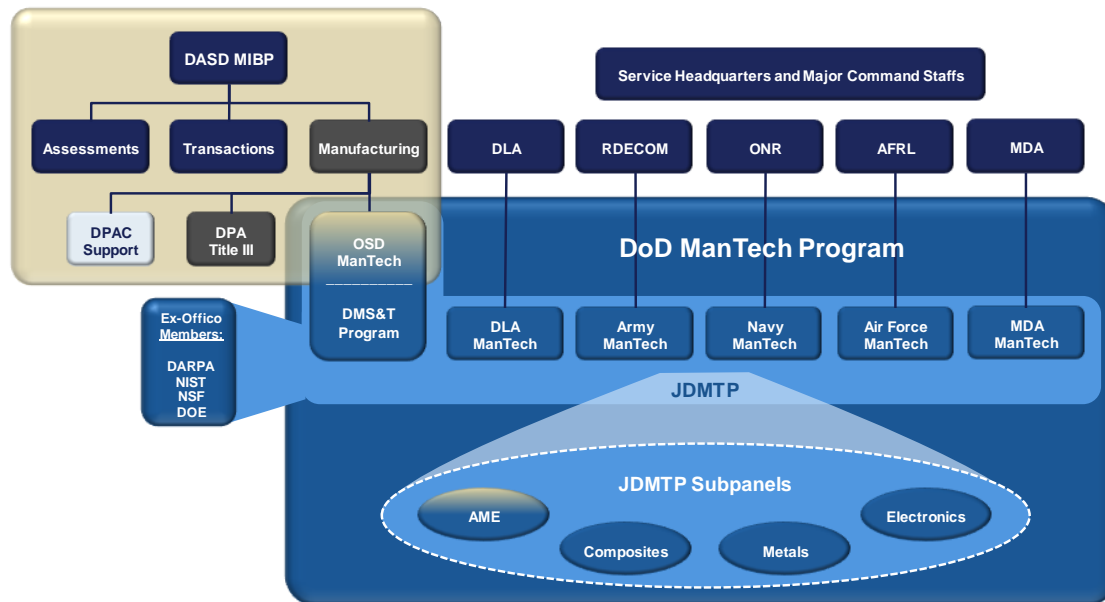
*throughout the defense system life cycle.* This vision captures the overriding imperative to satisfy Warfighter requirements across the spectrum of manufacturing activities, while doing so *affordably* and *rapidly*. Congress has long recognized this essential, enabling role, establishing ManTech in Section 2521 of Title 10, United States Code to:

*...further...national security objectives...through the development and application of advanced manufacturing technologies and processes that will reduce the acquisition and supportability costs of defense weapon systems and reduce manufacturing and repair cycle times across the life cycles of such systems.*

The program's mission is both multi-faceted and vital; namely, DoD ManTech anticipates and closes gaps in manufacturing capabilities for affordable, timely, and low-risk development, production, and sustainment of defense systems. The program looks beyond the normal risk of industry and directs investments at improving the quality, productivity, technology, and practices of businesses and workers providing goods and services to the DoD. ManTech's role as a crucial link between technology development and industrial application gives the program a unique and vital position within the defense industrial base and broader strategic security environment.



Section 2521 of Title 10, United States Code (10 U.S.C. 2521) requires the USD(AT&L) to administer the DoD ManTech Program on behalf of the SECDEF, and this is further delegated to the MIBP, which exercises OSD-level oversight of the ManTech Program pursuant to 10 U.S.C. 139c. Organizationally, this is accomplished via the MIBP's Manufacturing Directorate and the Manufacturing Technology office. Component ManTech programs are individually executed by the Departments of the Army, Navy, Air Force, the Defense Logistics Agency (DLA), the Missile Defense Agency (MDA) and OSD.



These Component programs collaborate and coordinate their efforts through the Joint Defense Manufacturing Technology Panel (JDMTP). The Component ManTech programs and the JDMTP organizational structures are also depicted. The Principals of the JDMTP are senior technology managers representing the Army, Navy and Air Force, DLA, MDA and OSD. The OSD Principal possesses the dual role of communication link to OSD as well as of manager of the DMS&T Program line. Ex-officio members of the JDMTP include DARPA, NIST, NASA, and DoE. The JDMTP categorizes ManTech investment areas by the technology portfolios of subpanels – the current subpanels are Electronics, Metals, Composites and Advanced Manufacturing Enterprise (AME) – enabling Component ManTech programs to maximize opportunities for shared investment in initiatives and strategies with joint application, and to prevent duplication of effort.

Component ManTech programs are each overseen and managed from within the S&T organizational structures of their associated DoD Component. Additionally, the DASD(MIBP), whose ManTech Office administers the DMS&T Program, is a member of the S&T Executive Committee (EXCOM) comprised of those key organizations in DoD that oversee and coordinate the S&T activities of the Department. Although all Component ManTech programs work in concert toward common goals, each has important focus areas to meet individual Component mission needs.

- The Army ManTech Program is structured around enabling manufacturing improvements of components and subsystems for ground, Soldier/squad, air, lethality and command, control, communications and intelligence systems.
- The Navy ManTech Program’s critical goal is to reduce the acquisition cost of current and future platforms, resulting in an affordability investment strategy currently focused on five ship platforms, and the F-35 and CH-53K aircraft.

- The Air Force ManTech Program is the DoD lead for manufacturing technology in aerospace propulsion, structures, and ISR and is the only Air Force corporate program working strategic issues and opportunities in manufacturing and industrial readiness. Manufacturing Technology plays a pervasive role in enabling many Air Force S&T Strategy priorities, chiefly through attaining next generation agile manufacturing.
- The DLA ManTech Program focuses on sustaining the Warfighters and improving materiel readiness; ongoing efforts support improvements in availability of microcircuits, combat rations, clothing and protective equipment, batteries, forgings, and castings.
- The OSD-managed DMS&T Program takes a broad, overarching view towards closing critical gaps in cross-cutting, military manufacturing enabling technologies that will have a significant impact on multiple Military Departments or platforms.

Please see Appendix C-2 for more details on each of these programs.

The JDMTP and MIBP jointly developed a 2012 DoD ManTech Program Strategy that recognizes the ManTech Program's central role within the defense manufacturing enterprise and its extended impacts and leverage across the defense industrial base and broader national security environment. Due to its length, the full DoD ManTech Program Strategic Plan is not included as part of this report, but it can be downloaded at:

[https://www.dodmantech.com/relatedresources/DoD\\_ManTech\\_Pgm\\_2012\\_Strat\\_Plan.pdf](https://www.dodmantech.com/relatedresources/DoD_ManTech_Pgm_2012_Strat_Plan.pdf). The theme of the strategy is *Delivering Advanced, Affordable Manufacturing for the Warfighter*, and the following four strategic thrusts (with supporting enabling goals) have been established to unify and guide the joint ManTech enterprise, consistent with the USD(AT&L)'s Better Buying Power initiatives and the defense manufacturing vision and ManTech Program mission:

- Thrust 1: A Responsive and Balanced Manufacturing Technology Investment Portfolio to Meet DoD Requirements
- Thrust 2: Active Support for a Highly Connected and Collaborative Defense Manufacturing Enterprise
- Thrust 3: Active Support for a Strong Institutional Focus on Manufacturability and Manufacturing Process Maturity
- Thrust 4: Active Support for a Healthy, Sufficient, and Effective Defense Manufacturing Infrastructure and Workforce

This framework establishes the program's core focus on ensuring responsiveness and balance across the full portfolio of manufacturing technology investments (Thrust 1), and it couples that focus with the objective to actively and collectively support broader defense manufacturing needs (Thrusts 2, 3, and 4). This approach underscores the importance of program support for these broader needs while recognizing it is beyond the program's charter and resources to fully satisfy them. Even so, each of these four thrusts directly supports the SECDEF's current

strategic guidance in key ways. In particular, processing and fabrication breakthroughs enable affordable production for effective modernization; material and manufacturing investments made concurrently with S&T R&D projects deliver technological superiority to the Warfighter quickly; and enterprise level initiatives create more connected and collaborative environments, a stronger focus on manufacturability, and improved manufacturing infrastructure. All of these support the maintenance of a healthier and more resilient industrial base.



The JDMTP is moving forward with joint planning and coordination on major weapon systems. In the case of the F-35 Lightning II, four ManTech projects, two Navy and two Air Force, directly impacted F-35 affordability. With a combined investment of \$14.5M, these initiatives are projected to reduce F-35 program costs by \$1.1B over 30 years of production. More importantly, these technology advances can be leveraged by current and future defense programs to reduce costs and bolster U.S. manufacturing capabilities.

Other successful projects include:

- Chip Scale Atomic Clock program enables precise timekeeping within C4ISR systems in GPS-denied environments, reduces unit cost from \$8,700 to ~\$400, raises unit production from 100/yr to 40,000/yr: potential savings is approximately \$291M.
- Army ManTech enabled affordable low light sensor for multiple weapon systems (Apache, Soldier Systems, F-35 JSF): increased life 10X, decreased cost 75%, ROI of 85-1 with \$907M cost benefit.
- Virginia Class Submarine (VCS) initiative- 36 of the Man Tech affordability projects have been implemented or are in process. Realized cost savings/hull of over \$32.4M have been recognized by the VIRGINIA Class Program Office and General Dynamics Electric Boat, returning the entire annual Navy ManTech Budget through VCS savings of greater than \$60M per year.

- Air Force ManTech delivers Vertical-cavity Surface Emitting Lasers (VCSELS) for Unmanned Aerial Vehicles, doubling yields and decreasing cost by 10X. VCSEL ManTech enables use in weapon illumination and rangefinders, low cost security, and laser welding.

Further joint planning and coordination are exercised by the JDMTP Subpanels. In response to the 2012 ManTech Strategy and particularly in support of Thrust 1, the JDMTP began to develop Joint Technical Pursuit Areas (JTPAs) as part of the annual planning cycle. Thrust 1 focuses on the need to balance mission-specific priorities of Service ManTech Programs with broader Joint-Service priorities which can deliver significant advantages to the Defense Industrial Base. JTPAs represent manufacturing challenges which cross-cut multiple Services and multiple systems; topics which are beyond the risk for a single Service, but which provide dramatic ROI through Joint-Service collaboration.

### **7.3 Manufacturing Innovation Institute**

The Administration has signaled the growing importance of advanced manufacturing to the economic and national security of the United States. Key examples include:

- The President's Council of Advisors on Science and Technology (PCAST) 2011 report, *Ensuring American Leadership in Advanced Manufacturing*;
- The 2011 establishment of the President's Advanced Manufacturing Partnership (AMP) initiative across government, industry and academia
- The 2012 State of the Union Address emphasis on manufacturing's importance to the nation;
- The 2012 release of the National Science and Technology Council's (NSTC) *National Strategic Plan for Advanced Manufacturing*;
- The formation of the Department of Commerce-hosted Advanced Manufacturing National Program Office (AMNPO) supported by DoD and other Interagency partners;
- The release of *Capturing Domestic Competitive Advantage in Advanced Manufacturing*, the final report from the Advanced Manufacturing Partnership Steering Committee created by the President;
- The 2013 State of the Union Address announcement of the formation of three new Institutes of Manufacturing Innovation, one led by DoE and two led by DoD;
- The 2013 launch of the Advanced Manufacturing Partnership Steering Committee "2.0;"
- The 2014 State of the Union Address announcement of four additional Institutes for Manufacturing Innovation; and

- The October 2014 PCAST report to the President *Accelerating U.S. Advanced Manufacturing*.

In support of these and the National Network for Manufacturing Innovation (NNMI) in particular, DoD provided key funding, technical leadership and program management support to successfully launch the \$110-Million “pilot” institute, the National Additive Manufacturing Innovation Institute. Now called ‘America Makes,’ the Institute officially opened on September 27, 2012, and it will serve as a training and collaboration center to bridge the gap between basic research and technology adoption for additive manufacturing technologies. More commonly known as “3D Printing,” additive manufacturing is an enabling manufacturing technology for our military platforms. Participants include the DoD, DoE, National Aeronautics and Space Administration, National Science Foundation, and the Department of Commerce's National Institute of Standards and Technology. The interagency investment of \$55M has been matched by a \$55M cost-share from non-federal sources, and this institute has the goal of becoming self-sufficient within five years.

Building upon that success, DoD then led an effort to launch two new public-private partnerships for Advanced Manufacturing on behalf of the Department: the Digital Manufacturing and Design Innovation (DMDI) Institute and the Lightweight and Modern Metals Innovation (LM3I) Institute. The \$176M DMDI Institute, headquartered in Chicago, IL focuses on enterprise-wide utilization of the digital thread, enabling highly integrated manufacturing and design of complex products at reduced cost and time. The digital thread captures information generated from concept development and design to analysis, planning, manufacturing, assembly, maintainability, and through to disposal. By demonstrating the potential for integrating information technology, smart factory processes, intelligent machines, and sophisticated analytics, a DMDI Institute will be a key competitive differentiator for the U.S industrial base. The \$148M LM3I Institute focuses on the design of lightweight systems, including the design of lightweight materials, the design of manufacturing operations to produce lightweight components, and the integration of these designs into revolutionary new lightweight systems. During the past 15 years, significant U.S. investments in lightweight metals, intended for demanding critical applications, have not transitioned into the marketplace due to cost of necessary scale-up and certification requirements. Defense, transportation, energy and automotive industrial segments all benefit significantly from lightweight structures and components. By integrating the emerging capabilities in materials design, and in process design, with the design of new lightweight components and products, the speed at which products enter the marketplace can be accelerated, at competitive price points, and drive global competitiveness.

Currently, DoD is working to establish three additional Institutes, with technical focus areas of Integrated Photonics Manufacturing, Flexible Hybrid Electronics Manufacturing, and Revolutionary Fibers and Textiles Manufacturing. The Integrated Photonics (IP) Institute will seek to advance integrated photonic circuit manufacturing technology development while simultaneously providing access to state-of-the-art fabrication, packaging, and testing capabilities for small-to-medium enterprises, academia and the government. IP applications include Ultra high speed data and communications, high-performance IT systems, medical

diagnostics, and multiple sensor integrations. Flexible hybrid electronics manufacturing is an innovative process at the intersection of the electronics industry and the high-precision printing industry, with the power to create sensors that are lighter in weight, or conform to the curves of a human body, while preserving the full operational integrity of traditional electronic architectures. Integrating ultra-thin silicon components—through high-precision handling, printing with conductive and active inks, and printing to integrate on stretchable substrates—flexible hybrid technologies can improve the connectivity of devices through the Internet of Things. Revolutionary Fiber and Textiles will focus on manufacturing of technical textiles, consisting of fibers and fabrics with extraordinary properties of strength, flame resistance, and electrical conductivity, among others. These technical textiles are built upon a foundation of synthetic, natural fiber blends and/or multi-material fibers that have a wide-range of applications, in both the defense and commercial sector that go beyond traditional wearable fabrics.

All six of these DoD Institutes, along with the two DOE-led institutes focused on wide bandgap semiconductor power electronics and advanced composites, will be members of the newly authorized NNMI to help inform the broader NNMI and AMP initiatives and directly support the national agenda to aggressively develop or help sustain world-leading advanced manufacturing capabilities, enabling U.S. industry to maintain its edge in a hypercompetitive global environment and to meet vital economic and national security needs. Congress authorized the establishment of a national network as part of the Revitalize American Manufacturing and Innovation (RAMI) Act of 2014.

#### **7.4 Industrial Base Analysis and Sustainment**

The IBAS Program was established in 2014 to address critical capability shortfalls in the Defense Industrial Base. Capabilities that are at-risk of being lost and cross Service/DoD-Agency boundaries are specifically targeted. The goal is not to sustain all capabilities indefinitely but to avoid reconstitution costs when capabilities are likely to be needed in the foreseeable future. IBAS makes investments only when sustainment is more cost-effective than reconstitution and results in overall cost savings to the Department.

The three areas of IBAS focus are:

- Unique Capabilities – Lifelines and Safe Harbors for critical, unique capabilities with fragile business cases.
- Design Teams – Preserving Critical Skills for technological superiority.
- Industrial Base Supply, Expansion & Competition – Supporting expansion of Reliable Sources.

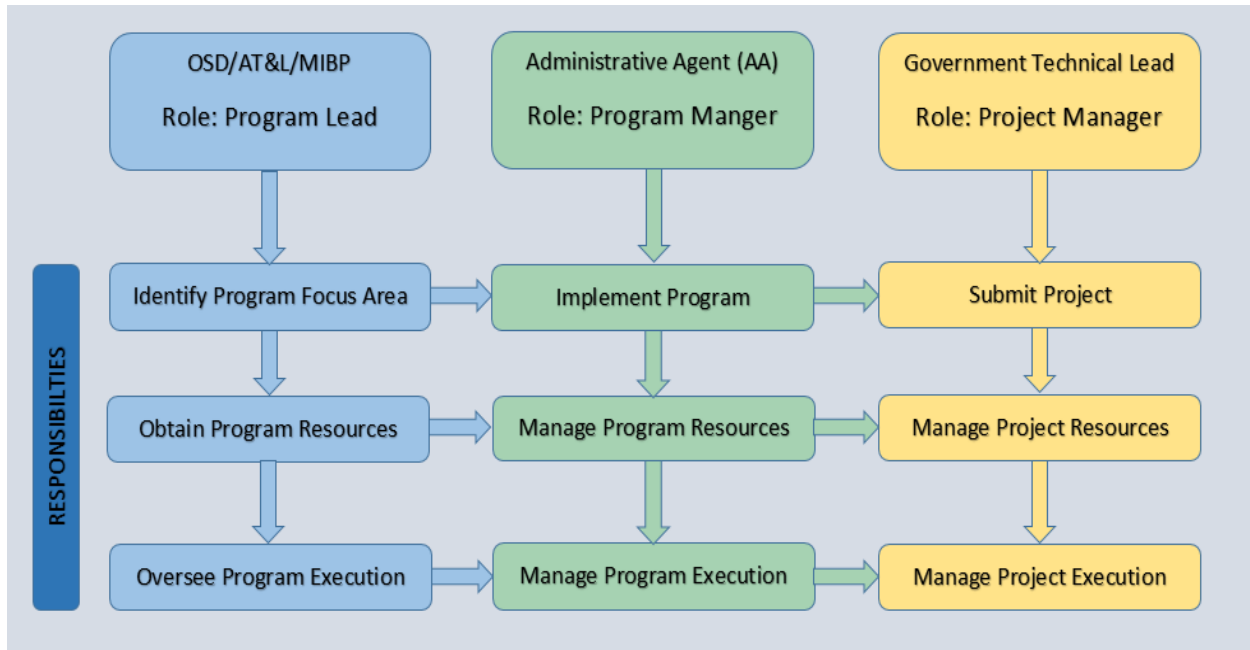
Proposals for IBAS funding are evaluated in a four step process. First, proposals are scored with established fragility and criticality criteria. Fragility examines characteristics that make a specific capability likely to be disrupted. Criticality examines characteristics that make a specific capability difficult to replace if disrupted. Second, proposals are reviewed for alignment with IBAS objectives. Third, proposals are ranked by a multi-Service/multi-Agency Joint



Industrial Base Working Group (JIBWG) review panel. Fourth and finally, MIBP evaluates the review panel results and makes the final selections for IBAS funding.

The IBAS Program is executed according to the following framework.

Figure 7.4.1: IBAS Program Framework



The ultimate responsibility for program execution lies with MIBP. The office is responsible for ensuring the areas being addressed are based upon the latest vulnerability information associated with the Defense Industrial Base. Focus areas can change year to year for a variety of reasons including budget shifts, changes in risk, and technology advancements that can render current capabilities obsolete.

While MIBP is responsible for submitting and tracking the annual budget requests and for execution, they depend upon an Administrative Agent for actual day-to-day management of the program. This agent calls for project proposal submissions, tracks project progress, and interacts with the individual government technical leads who directly liaison with the principle performers of the work. They follow the program strategy as directed by the MIBP program office while pre-screening all proposals submitted for consideration and provide an evaluation and ranking to the JIBWG review panel.

Sources for IBAS project ideas come from a variety of different sources. A general call for proposals can be sent to the DoD Service Acquisition Executives and Agencies. Sector specific working groups, such as the SIBWG or the CEMWG can engage the IBAS program office directly. Additionally, industrial base FaC assessment results can be used to target specific areas of concern.

## Program Details

Since program inception, the IBAS program has sponsored 10 major efforts during Fiscal Years 2014 and 2015. These programs have preserved fundamental capabilities across the Industrial Base in all three of the IBAS focus areas. A brief synopsis of these efforts is provided below.

### Lifelines and Safe Harbors – Preserving Unique Capabilities

- *Counter Bomber*: IBAS has sustained this unique suicide bomber detection capability that was in fiscal jeopardy as declining troop deployments reduced demand. This system will now be enhanced and available to be utilized in military and commercial applications both domestically and abroad.
- *Cyclotron*: This rare capability to perform radiation testing on space hardened components was preserved by IBAS at the University of California, Berkeley. Using ion “cocktail” beams, parts are pre-qualified to ensure they meet standards required to reduce in-service failures before they are deployed into space.
- *Electromechanical Actuator Planetary Roller Screw*: IBAS sustained the domestic capability to produce non-commercial actuators tailored to unique Navy requirements. Government lifecycle funding anomalies jeopardized timely procurement and sole source provider viability of the elevator actuator system used in the Ford Class aircraft carriers and the Littoral Combat System (LCS) Class ships.
- *Thermal Batteries*: The decline in missile production has made the industrial base for thermal batteries very fragile. Production is falling below minimum sustaining rates. IBAS has initiated three projects for thermal battery technical improvements in battery materials and shelf life that will lower minimum sustaining rates: improved material composition that will provide additional domestic suppliers, characterization of Thermal Battery shelf-life model to enhance production quality and sustainment (reducing costs and industrial base burden), and improved thin film production to broaden and improve the market.

### Design Teams – Preserving Critical Skills

*FPA's - Next Generation Development*: IBAS preserved an industry design team capable of performing the design research necessary to advance the next generation of FPA's. Maintaining this design team averted an imminent sole source situation. This project will have a positive impact on the ground vehicle and aircraft DoD industrial base sectors for years to come.

*Mercury cadmium telluride (HgCdTe) production for FPA's*: The IBAS program preserved a valuable design team responsible for advancing the production of mercury cadmium telluride. Infrared (IR) detectors play a critical role in detecting and monitoring defense and meteorological events on both terrestrial and space electro-optical (EO) systems. There is currently only one affordable solution for these systems – HgCdTe. No other detector material exists today that has demonstrated comparable performance or TRL/MRL levels as HgCdTe. If

HgCdTe FPA manufacturing capability was lost, the United States would not have the superior capability to see first, most, and farthest. Volumes for HgCdTe wafer fab production have fallen below the historical annual average for the past 7 years. The business case for this situation has resulted in deep staffing cuts of skilled operators. Further reductions will require making radical decisions to down-scale capability.

*Advanced Solid Rocket Propulsion:* This IBAS project focused on supporting and maintaining a design team with special talents for developing weapon systems applications using solid rocket propulsion. This project resulted in a new Solid Diverter and Attitude Control System (SDACS) which can be used in future missile interceptor missions with advanced kill vehicle thrusters for high precision and long duration missions. This project enhanced the DACS capability in the U.S. specifically cited as an industrial base concern by Congress.

*Fuzes:* Because of the decline in missile production, fuzes are experiencing a decline in production, making the industrial base very fragile. Without intervention, loss of industry design and production expertise is expected for ESAD-based fuzes. ESADs are most commonly used in missile fuzing, but have applicability to some of the Department's most critical gun fired and air delivered munitions as well. To improve the industrial base capability, IBAS is funding EASD design projects for cost reduction and commonality across multiple missile and munition end-products. Phase I was initiated by contracting with three different suppliers to exercise their engineering capability, including the use of sub-tier suppliers and component technology, to develop lower cost, common architecture ESAD designs. These three suppliers form the critical core of the U.S. Industrial Base for fuzes overall. Phase II is planned for award in FY 2017. In this phase the work from Phase I will then be applied against a post milestone C munition which can benefit the most from an upgraded fuze capability.

#### Industrial Base Supply, Expansion & Competition – Expanding Reliable Resources

*Butanetriol:* The IBAS program addressed a sole source situation for this critical energetic ingredient used as a rocket propellant precursor chemical. The sole source was also a prohibited source. Major process engineering and a minor modification to a defense contractor facility enabled the first full-rate domestic production of this material since 2002. This project will ensure the sustainment of this capability across many DoD programs including the HELLFIRE, JAGM, TOW, Javelin, Griffin, AIM-9x, AEGIS and Chaparral weapon systems.

*Low Energy Expanding Foil Initiator:* This IBAS project established a second reliable source for an at-risk producer of detonators used by 12 key DoD weapons systems.

*Radiation Hardened Bi-polar Transistors:* IBAS preserved a second source for technology vital to National Security. These particular components are used on most space-based platforms and strategic military systems. The Trident program also heavily relies on these components.

IBAS is successfully supporting the National Defense Strategy by maintaining and improving the health of critical and fragile IB capabilities that are at risk of being lost. Projects address cross-service capabilities at risk “falling through the cracks.” The IBAS sustainment of

these capabilities has shown great success in keeping critical industrial capabilities alive, enhancing the readiness and effectiveness of our National Defense, and lowering total cost to DoD.

## **Conclusion**

CY2014 witnessed continuing steady progress in the Defense Department's effort to maintain and develop the nation's defense industrial base. With the Administration's support, DoD advanced several broad goals:

- Improved federal inter-agency cooperation across the board, with MIBP assuming a stronger leadership and catalyst role in DIB assessment and mitigation process.
- Refined MIBP's assessment methodology to target the most vulnerable procurement sectors, using subject matter experts to drill down into specific tiers and sub-tiers to identify priority mitigation targets.
- Incorporated DIB mitigation plans and funding into annual DoD budgets requests and additional supplemental appropriations.

MIBP leads DoD's efforts to address and mitigate the Department's industrial base concerns through the establishment and utilization of various programs and activities. Highlights of 2014 activities include:

- Seven FaC assessments conducted to identify industrial base risks and vulnerabilities,
- Establishment of two new Manufacturing Innovation Institutes, LIFT and DMDI, and efforts to establish three additional institutes in 2015,
- Initiation of ten IBAS projects to preserve fundamental industrial capabilities primarily in the missile and space industrial sectors,

Government and industry stakeholders are keenly aware of significant ongoing pressures on the industrial base. Firms struggle to conduct long-term planning for their investment strategies as they seek to realign their business activities to compete in fast-changing markets. The prospect of more sequestration – and doubts about future defense procurement funding – leaves many firms no option but to focus narrowly on sustainment at the cost of R&D design and innovation. The firms that succeed in this environment need to make strategic investments now but many are reluctant to do so.

The Department is deeply concerned about the loss of technical expertise and design teams that are sustained through new program development. Over the past decade, many industrial sectors – including several reviewed in this report – have had no or few new-start opportunities in defense-specific areas that are currently undergoing a decline in procurement. The combination of loss of design and production capability could result in costly delays and unanticipated expense, creating a significant negative impact on the development of next-generation weapon systems to meet tomorrow's Warfighter needs.

MIBP continued the work it began in 2013 to refine the S2T2 process established in 2010 with a more technically rigorous and timely methodology for identifying and mitigating

weaknesses in the DIB based on the broad framework established earlier by the Department. This refined methodology is now called a FaC assessment. Over the next year or two, MIBP plans to develop predictive tools to enhance its efforts to refine this methodology.

Continued sequestration and prolonged budget uncertainty could affect capital market confidence across the defense industry, undermining companies' willingness or ability to continue to invest in their defense portfolios. Continued uncertainty will hit smaller, innovative, and niche product companies particularly hard, due to their lack of capital resources to withstand market turmoil and uncertainty. The threat of global supply chain disruptions is also growing. While only a fraction of our industrial base capabilities are currently at risk, this could change if business confidence in the future of the defense sector continues to decline.

In short, this is no time to let up on our efforts. Continuous improvements in the DIB assessment methodology with improved targeting and closer interagency and government-private sector collaboration are needed to help navigate the Department through a turbulent and difficult time. Additional Congressional funding would also be welcome to bolster our short-term risk mitigation and to begin tackling more squarely the array of adverse impacts on the DIB identified in this report.

## **Appendix A - Annual Report Requirements**

Section 2504 of title 10, U.S.C., requires that the Secretary of Defense submit an annual report to the Committee on Armed Services of the Senate and the Committee on Armed Services of the House of Representatives, by March 1<sup>st</sup> of each year. The report is to include:

- (1) A description of the Departmental guidance prepared pursuant to section 2506 of this Title.
- (2) A description of the methods and analyses being undertaken by the DoD alone or in cooperation with other Federal agencies, to identify and address concerns regarding technological and industrial capabilities of the national technology and industrial base.
- (3) A description of the assessments prepared pursuant to section 2505 of this Title and other analyses used in developing the budget submission of the DoD for the next fiscal year.
- (4) Identification of each program designed to sustain specific essential technological and industrial capabilities and processes of the national technology and industrial base.

Section 852 of the NDAA for FY 2012 required that the annual report to Congress on the defense industrial base submitted for fiscal year 2012 pursuant to section 2504 of title 10, U.S.C., include a description of, and a status report on, the sector-by-sector, tier-by-tier assessment of the industrial base undertaken by the DoD. As required, the report included a description of the steps taken and planned to be taken:

- (1) To identify current and emerging sectors of the defense industrial base that are critical to the national security of the United States;
- (2) In each sector, to identify items that are critical to military readiness, including key components, subcomponents, and materials;
- (3) To examine the structure of the industrial base, including the competitive landscape, relationships, risks, and opportunities within;
- (4) To map the supply chain for critical items identified under paragraph (2) in a manner that provides the DoD visibility from raw material to final products;
- (5) To perform a risk assessment of the supply chain for such critical items and conduct an evaluation of the extent to which:
  - (a) the supply chain for such items is subject to disruption by factors outside the control of the DoD; and
  - (b) such disruption would adversely affect the ability of the DoD to fill its national security mission.
- (c) Follow-up Review.—The Secretary of Defense shall ensure that the annual report to Congress on the defense industrial base submitted for each of fiscal years 2013, 2014,

and 2015 Includes an update on the steps taken by the DoD to act on the findings of the sector-by-sector, tier-by-tier assessments of the industrial base and implement the strategy required by section 2501 of title 10, U.S.C. Such updates shall, at a minimum—

- Be conducted based on current mapping of the supply chain and industrial base structure, including an analysis of the competitive landscape, relationships, risks and opportunities within that structure; and
- Take into account any changes or updates to the national defense strategy, National Military Strategy, national counterterrorism policy, homeland security policy, and applicable operational or contingency plans.

The Senate Report 112-26 accompanying S. 1253, the NDAA for FY 2012, noted at pages 65-66 that the Senate Armed Services Committee is interested in how the determination of DPA Title III projects will be linked to the outcome of the S2T2 assessments, which would identify sectors of the defense industrial base that may require additional resources. The committee requested the DASD(MIBP) to submit an annual report by April 1, to the congressional defense committees containing a prioritized list of potential investments required to address industrial base shortfalls to be expected to be funded by the Department in future years through the DPA Title III program.

This report contains the required information.

This report simultaneously satisfies the requirements pursuant to Title 10, U.S.C., section 2504, which requires the DoD to submit an annual report summarizing DoD industrial capabilities-related guidance, assessments, and actions and Senate Report 112-26, which accompanied the NDAA for FY 2012, and requires a report containing a prioritized list of investments to be funded in the future under the authorities of Title III of the Defense Production Act.

## **Appendix B – Summary of Key Industrial Capabilities Assessments Completed During CY 2014**

This appendix summarizes assessments conducted by the Military Departments and Defense Agencies during 2015. It is classified For Official Use Only Business Sensitive. For access, contact the Office of Manufacturing and Industrial Base Policy, 703-697-0051.

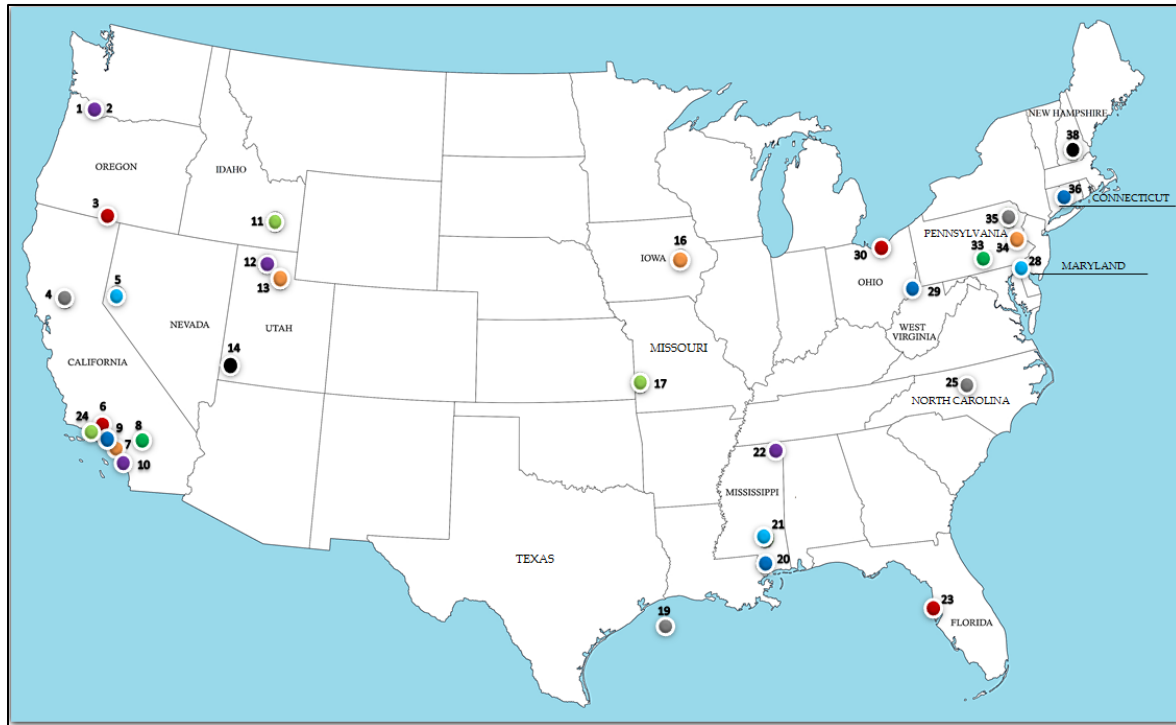


## Appendix C – Related Activities

### C.1 Title III – Defense Production Act Summaries



## DPA Title III Projects – Active in 2014



### Additive Manufacturing for Liquid Rocket Engines Project (Map Location #24)

Awarded in July 2014, this project aims to advance the domestic capability for precision manufacturing of components utilized by National Security Space (NSS) agencies to launch critical assets into Earth orbit. Advanced additive manufacturing equipment, now being deployed, provides up to a 600% volumetric increase in the powder bed compared to existing additive manufacturing equipment. This essential equipment provides the necessary build envelope and capabilities to produce larger critical components for liquid rocket engines.

The industrial base for precision manufactured components for LREs is high cost and is facing component obsolescence challenges. Direct Metal Laser Sintering (DMLS), an additive manufacturing technique, is estimated to provide a 30% to 80% reduction in critical component cost and schedule for upper stage precision manufactured components. Under this effort, the contractor will establish and ex-situ qualify the production of various RL10 and RS-68 nickel, aluminum, and copper LRE components.

Total government funding for this project is \$6.29M, augmented by \$5.46M of contractor cost-sharing. Government funding is provided by members of the Space Industrial Base Council's Critical Technologies Working Group, under the terms of a MOA with the Title III office.

### **Advanced Carbon Nanotube Volume Production Project (Map Location #38)**

This Title III project is providing infrastructure for the world's first industrial scale manufacturing facility producing carbon nanotube (CNT) yarn, sheet, tape, and slurry materials. These materials provide the Warfighter improved protection and survivability, while improving mission effectiveness and reducing operating costs. Project emphasis is on increasing output volume by expanding flexible, scalable, and modular production processes; improving product availability, quality and yield; and reducing manufacturing costs.

Carbon nanotubes exhibit extraordinary strength, unique electrical properties, and are highly efficient thermal conductors. They are the strongest and stiffest materials discovered in terms of tensile strength and elastic modulus respectively. CNT materials conduct electricity, shield from electro-magnetic interference and electromagnetic pulses, block flames, and enhance ballistics protection, while being impervious to corrosion, heat and cold, or sunlight degradation. CNT yarn, sheet, tape and slurry based-products have shown they can successfully operate in broader temperature ranges, radiation levels, or corrosive environments than conventional materials.

This project initially established an operational pilot facility for the manufacture of CNT material for test and evaluation purposes. Tens of thousands of square feet of sheet material and thousands of kilometers of yarn made in this facility have been delivered to customers. From this contractor, CNT Electro-Static Discharge/Electro-Magnetic Interference shielding has achieved a Technology Readiness Level (TRL) of 8/9 for spacecraft, while CNT heaters, data cables, enhanced soft and hard ceramic armor have all achieved TRL 6.

The project most recently funded expansion from Pilot to Low Rate Initial Production (LRIP) level, with a 2015 start date. When completed, this expanded capability will, for the first time, provide tonnage quantities of advanced CNT products sufficient for qualification and initial insertion into programs for aerospace, ballistics protection, and aircraft.

This project was funded through Congressional increase to the Title III budget. DPA Title III funding is \$24.76M, augmented by \$25.19M of contractor's cost-share.

### **Advanced Complementary Metal Oxide Semiconductor Focal Plane Arrays (FPA) for Visible Sensors for Star Trackers Project (Map Location #2)**

This project will expand and enhance the domestic industrial base's ability to produce visible - imagers manufactured using advanced CMOS technology. Advanced CMOS imagers are designed to enable flexible visible imaging systems on-board satellite and other systems for DoD and other U.S. Government needs. Current domestic Star Tracker manufacturers are using older, more expensive, and less capable CCD sensor technology that has put domestic suppliers at a disadvantage with international competitors. This project will insert critical technology into the defense industrial base and ensure a level playing field for Star Tracker production.

Staring Technology for Enhanced Linear Line-of-site Angular Recognition (STELLAR) chip specification and testing framework acceptance have been achieved. Second Cycle of Learning (COL) Pixel Design Arrays (PDA2s) are in fabrication and will be completed in 2015.

PDA1 designs have completed radiation effects analysis and are meeting threshold limits. Total government funding for this project is \$12.54M, augmented by \$4.24M of contractor cost-sharing. Government funding is provided by members of the Space Industrial Base Council's Critical Technologies Working Group, under the terms of a MOA with the Title III Office. This effort was sourced through a competitive solicitation.

### **Advanced Drop-In Biofuel Production Project (Map Locations #3, 5, 19)**

The objective of this project is to form one or more Integrated Biofuel Production Enterprises (IBPEs) comprised of partnerships that establish the complete value chain and are capable of producing drop-in replacement biofuels. The project was initiated in support of the Departments of the Navy, Energy and Agriculture to partner with private industry and accelerate the commercialization of drop-in biofuels for military and commercial use. "Drop-in fuels" can utilize existing infrastructure, are delivered to DoD fully blended with conventional petroleum product counterparts JP-5, JP-8 (aviation fuels) and/or F-76 (naval diesel), and are ready for use with no modification to distribution infrastructure or aircraft/ship equipment systems.

The three Departments developed a plan to invest over multiple years to spur private industry and financiers to match Title III funds for the construction or retrofit of multiple commercial-scale integrated biorefineries. Each proposed biorefinery must be based in the U.S. or Canada, use renewable biomass from acceptable domestic sources, comply with the Energy Independence and Security Act (EISA) and produce a minimum of 10 million gallons of neat fuel annually.

A two-phased approach is being executed. In Phase 1 of the program, the DoD, acting through the Air Force, DoD's Executive Agent for the DPA Title III Program, awarded four contracts totaling \$20.5M of government funding for an initial 15-month effort, subsequently extended to 24 months. Phase 1 involved validation of production technology, verification of technical maturity, site selection, plant design, permitting, detailed cost estimation, environmental assessment and contractor financial closing with commercial financial markets. Each Phase 1 Contractor was required to match government funding with its own funds on a minimum 1:1 basis.

All Phase 1 Awardees submitted a Phase 2 follow-on proposal from which three were down-selected and awarded a Phase 2 effort in August 2014. Phase 2 activities involve finalizing detailed design and engineering plans, physical plant construction & mechanical completion, start-up and initial operations, plant performance testing, and commencement of routine operations. Government cost-share funds will be deployed to purchase commercial manufacturing equipment, engineering & design services and prime contractor labor charges. Following financial close, 30 – 36 months will be required to complete all Phase 2 activities and achieve full-rated production capacity.

This competitively solicited project is being funded through increases to the Title III budget made by the DoD and Department of Energy. Title III funding for Phase 1 activities of \$20.5M is augmented by \$23.5M of contractor cost-sharing. Total Title III funding for Phase 2 activities is \$210M (\$70M each), augmented by a total \$700M of contractor cost-sharing.

### **Bio-Synthetic Paraffinic Kerosene (BSPK) Project (Map Location #8)**

The objective of this project is to establish a domestic, large-scale, commercial, feedstock flexible, manufacturing capacity of Bio-Synthetic Paraffinic Kerosene (BSPK). BSPK is a biomass derived fuel product with strategic importance for diversifying U.S. energy sources, achieving energy security, and increasing environmental stewardship. Energy security and environmental stewardship for the DoD requires unrestricted, uninterrupted access to affordable, clean energy sources to sustain mission objectives. Biomass based fuels are an attractive alternative to petroleum based fuels since they are produced using renewable resources and can be exploited using more environmentally friendly technologies. The U.S. military's lack of diversified fuel options could negatively impact mission capabilities if crude oil supplies were disrupted.

Anticipated output from this project will be 20 to 28 million annual gallons of renewable distillate (renewable diesel and BSPK), which will be achieved by retrofitting portions of an existing oil refinery in Paramount, California. The retrofit, a \$25.2M cost-share venture between the U.S. Government and industry, will consist primarily of revamping and/or installing hydro-processing units and other supporting equipment. The Technology Investment Agreement (TIA) was executed 21 Sep 2012.

This project was funded through a Congressional increase to the Title III budget. Total Title III funding is \$3.61M, augmented by \$21.6M of contractor cost-sharing. This was a sole source solicitation as only a single domestic source was identified for the specific technology of interest.

### **CO<sub>2</sub> Absorbent Reactive Plastic Project (Map Location #28)**

Calcium hydroxide and lithium hydroxide CO<sub>2</sub> absorbent plastics are materials that actively absorb CO<sub>2</sub> from the air in environments such as submarines, underwater breathing systems, medical anesthesia, and mines. If left unchecked, increased CO<sub>2</sub> levels lead to impaired thinking, unconsciousness, and in extreme cases, even death. CO<sub>2</sub> absorbent materials traditionally are found in raw granule form, either packed in canisters or sprinkled loosely on the floor (of a submarine or a mine) in a survival situation. Reactive plastic CO<sub>2</sub> absorbent material encapsulates the absorbent chemistry into a plastic matrix or sheet thereby locking the absorbing material in place, and minimizing hazardous dust exposure to the surrounding air. In comparison to existing granular solutions, these reactive plastic CO<sub>2</sub> absorbent products improve the rate of CO<sub>2</sub> absorption by as much as 300%, improve absorbent capacity, reduce the size and weight of absorbers (i.e., 35% more absorbent in the same storage footprint of lithium hydroxide granules used on submarines), and eliminate dusting exposures to personnel.

ExtendAir® material is used to control the atmospheric CO<sub>2</sub> levels in sealed environments such as military submarines, military and commercial diving rebreathers, personal escape devices, and mine safety shelters. Various "first responder" rescue systems are also beginning to use this new material. The emerging SpiraLith™ product is now used in medical anesthesia machines in both VA and commercial hospitals.

The goal of this Title III project is to expand the domestic production capability to meet the DoD's needs for calcium hydroxide and lithium hydroxide CO<sub>2</sub> absorbent plastics. Industry has increased its extraction capacity six-fold while improving calcium and lithium hydroxide yields by 39% and 23%, respectively. Technology insertions include: retrofit of all Virginia-class U.S. Navy submarines, completion of three combat diver rebreather platforms (currently undergoing final warfighter evaluation by the U.S. Navy), newly qualified Emergency Escape Breathing Device (EEBD) systems for U.S. Navy shipboard personnel fire escape and rescue, certification of absorbent for Mine Safety and Health Administration (MSHA) refuge shelters, and the successful introduction of new anesthesia machine absorbents in both VA and commercial hospital emergency rooms. The project is currently focusing on cost reduction, material recycling, and market penetration into both the military diving and medical anesthesia markets. The project will conclude in March 2015.

Total project value is \$16.34M. Title III obligated \$14.07M, and the industry partner contributed \$2.27M in additional contractor cost-share. This was a sole source solicitation as only a single domestic source was identified for the specific technology of interest.

### **Coal-Based Carbon Foam Project (Map Location #29)**

Coal-based carbon foam (CFOAM) is an inexpensive, lightweight, fire-resistant, impact-absorbing material that can be fabricated in a variety of shapes, sizes, and densities. It replaces conventional materials that are heavier, more costly, offer lower structural capability, and present fire hazards. Its electrical conductivity can be varied over nine orders of magnitude, and it has a low coefficient of thermal expansion.

Carbon foam's applications include lightweight tooling, blast mitigation panels, and hot structure applications. Exhibiting properties similar to alternative materials, but available at a lower cost, carbon foam outperforms other products in noise reduction, fire resistance, impact resistance, energy absorption, and thermal properties. The goal of this Title III project is to expand the domestic production capability for coal-based carbon foam to meet the DoD's needs for blast mitigation, hot structure applications, and low-cost tooling.

During the project, industry increased CFOAM production capacity by 30%; implemented process improvements; yielded an overall material cost reduction of 35%; and developed a rapid prototype composite tooling surface, which reduced fabrication time by 75% and cut overall prototype tooling costs in half. In 2013, an 8 ft. x 25 ft. high-temperature/high-pressure horizontal autoclave was installed, increasing CFOAM capacity three-fold, from 8,500 cubic ft. to more than 36,000 cubic ft. annually.

This project was funded through Congressional increase to the Title III budget. Total Title III funding is \$15.0M, augmented by \$1.4M of contractor cost-sharing. This was a sole source solicitation as only a single domestic source was identified for the specific technology of interest.

### **Conductive Nano-Materials Scale-Up Initiative Project (Map Location #13)**

This Title III project is establishing a domestic source for high performance chemical vapor deposition (CVD) coated materials to solve current and future warfighter materials

problems. Conductive nickel coated-materials produced using CVD based processes have created lightweight structural composites that deny or survive any electromagnetic threat, either manmade or natural, across the electromagnetic spectrum. The project is scaling up coatings capabilities utilizing commercially available materials (nickel, carbon substrates) to construct nickel-coated fibers and nano-materials that can be subsequently blended into a normally non-conductive substrate (i.e., polymers, paints) to make them conductive. Nickel CVD coated carbon fibers provide light weight shielding capabilities. Project tasks include: development of a comprehensive production expansion plan; evaluation (and implementation) of critical processes for optimization; and improvement of product quality, yields, and production cost reduction. Title III focuses on business and marketing planning activities to monitor long-term growth of industry partners. Emphasis is being placed on business planning and activities that will support sustainable economic viability.

To date, the project has installed a second nickel-CVD (NiCVD) fiber coating machine, increasing capacity fourfold, a modified and upgraded NiCVD nonwoven coating machine has increased capacity fivefold, and a new organo-metallic gas synthesis unit doubled capacity. The industry partner is in the process of moving their manufacturing facility to a new location, construction of which began in February 2014, to be completed in November 2015. Partial production capabilities will be available by summer 2015.

This project was funded through Congressional increase to the Title III budget. Title III government funding is \$6.046M across Phases I - III. This was a sole source solicitation as only a single domestic source was identified for the specific technology of interest

### **Extremely Large Domestic Expendable & Reusable Structures (ELDERS) Project (Map Location #22)**

The objective of this Title III project is to ensure a dedicated source for the manufacture of larger-scale diameter composite structures to satisfy defense and non-defense U.S. space industry requirements. The project includes: the evaluation and modification of current production facilities; the procurement, installation, startup, qualification, and operation of an advanced machining center; procurement of an automated ultrasonic inspection system; the development and procurement of a combined Automated Tape Laying & Fiber Placement Machine [known as a Dockable Gantry System (DGS)]; as well as procurement of other ancillary support equipment. Driven by the need for improved fuel efficiency and operability, composite materials are commanding an important role in airframe, engine structures, and space launch vehicles. Automated composite technologies and improved non-destructive inspection techniques are being implemented to deliver affordable, high performance parts and assemblies for the DoD and the U.S. aerospace industry. Several DoD and NASA programs will benefit through the efficient and expanded production of larger scale components. Such programs include those applications requiring crew and heavy-lift cargo transport capabilities. These systems will provide mission support for continued crew transfer and logistics supporting the International Space Station, current and future space crew exploration vehicles, and payload/satellite deliveries.

The industry partner made significant progress with building the Dockable Gantry System at the machine fabrication shop, and completed the foundational concrete pour for the DGS.

Continued development and extensive software testing are in process. DGS shipment and installation are anticipated in 2015.

This project was funded through Congressional increase to the Title III budget. Total Title III funding is \$14.3M, augmented by \$9.62M of contractor cost-sharing.

#### **Gallium Nitride Advanced Electronic Warfare Monolithic Microwave Integrated Circuit Producibility Project (Map Location #9)**

The objective of this Title III project is to establish a domestic, economically viable, open-foundry merchant supplier production capability for Ka-band GaN MMICs. The overarching goal is to achieve Manufacturing Readiness Level (MRL) 8, meaning the process is ready for Low Rate Initial Production (LRIP) in a DoD acquisition program. This MRL target will be achieved through the application of process improvement techniques such as Six Sigma and LEAN manufacturing to reduce process variation and enable repeatable MMIC performance and reliability. This project leverages prior Government sponsored work by DARPA, AFRL, and ONR/NRL.

Testing and evaluation is complete to determine GaN MMIC yield, cost, capacity, and cycle time of the four baseline Manufacturing Readiness Assessment (MRA) lots. With the exception of cycle time, the contractor either met its target in Year 1 or came very close to the target. The 100mm GaN MMIC production Manufacturing Readiness Level has increased from MRL 5 (Components in Production Relevant Environment) to MRL 6 (System or Subsystem in Production Relevant Environment). The mid-term MRA was initiated in May 2014. Four lots of wafers (24 wafers total) are being fabricated and tested again to assess the current GaN MMIC yield, cost, cycle time, capacity, and MRL.

This project is funded in part with offsets transferred to the Title III budget from the Navy. Total government funding is \$8.6M, augmented by \$8.6M of contractor cost-sharing. A single contract was awarded in January 2013 in response to a competitive 2012 BAA solicitation.

#### **Heavy Forgings Capacity Improvement Project (Map Location #34)**

The purpose of this Title III project is to upgrade and refurbish heavy forging manufacturing equipment. DoD applications include propulsion shafts for surface and sub-surface naval vessels, periscope tubes, ring forgings for bull gears, and reactor vessels.

Heavy forgings are unique in that they require a 10,000 ton open die forging press to produce parts that begin with ingots up to 11 feet in diameter and weighing up to 600,000 lbs. In addition to the press, other special requirements include ingot manipulators, forge furnaces, treatment furnaces, specialized machine tools, building foundations, and structural capacity to support the processing of such heavy ingots. The focus of this Title III project is to address production constraints and single points of failure that are critical to maintaining the supply of heavy forgings to the DoD.



Major accomplishments in Phase I include the upgrade of a vertical boring mill, the installation of a 90' 75/25 ton overhead crane, and the structural overhaul of the contractor's 10,000 ton open die forging press.

In September 2013, a Phase II effort was awarded and included activities to increase capacity, provide new capabilities, and address potential high consequence events. Some of the tasks being executed include: improvements to a 3,000 ton open die forging press, procurement of ultrasonic inspection equipment, and installation of a multi-axis vertical boring mill.

The total project funding level is \$23.9M, which includes Government funding of \$20.5M and Contractor Cost-share of \$3.4M. The contractor has invested an additional \$11.5M in unrecognized cost-share to demonstrate commitment to the heavy forging business in support of the DoD. This was a sole source solicitation as only a single domestic source was identified for the specific technology of interest.

### **High Homogeneity Optical Glass (HHOG) Project (Map Location #35)**

This Title III project is structured to increase manufacturing capacity, optimize production yields, and ensure greater availability of affordable HHOG products. HHOG blanks are the basic building blocks in the fabrication of high precision optical lens systems, which are key technology drivers for several commercial, defense, and national security related applications. H4 grade and higher HHOG blanks are characterized as possessing a maximum refractive index variation across the entire optic of  $\pm 1.0 \times 10^{-6}$ . If the refractive index is non-uniform, or non-homogeneous, then light rays passing through the material at different locations will be bent in random directions and in an amount approximately proportional to the non-homogeneity. This can have several effects depending on the application.

The primary goals of this project include increasing manufacturing capacity, optimizing production yields to greater than 70%, and ensuring greater availability of non-active and active HHOG products. Project goals will be achieved via improvements to raw materials and enhancements to production processes and associated control systems. The DoD is particularly concerned with lens products required in optical designs for aerial, satellite and other space surveillance equipment.

To date, the industry partner has built customized power control cabinets, made enhancements to the forming system, retrofitted annealing ovens, acquired optical lens manufacturing equipment, and improved raw material blends. Technicians produced large format non-active and active optical glass for DoD and commercial applications.

This project was funded through Congressional increase to the Title III budget. Total Title III funding is \$5.8M, augmented by \$5.5M of contractor cost-sharing. This was a competitive solicitation.

### **Integrated Advanced Composite Fiber Placement (IACFP) Project (Map Location #12)**

The objective of this Title III project is to expand the U.S. domestic industrial base capability for the production of large aerospace composite products employing advanced fiber

placement technologies. Fabricating and installing state of the art production equipment will provide manufacturing efficiency improvements of 30% or better.

Automated Fiber Placement technology enables the efficient placement of composite fibers directly onto complex geometry tooling such as that required for a wing contour. The automated fiber placement process includes the ability to mechanically place composite material in a convex contour at higher degree angles. Unlike other manufacturing processes, it applies a band of material (in individual tows or tape) directly normal to the surface of the part, while applying pressure and heat to enhance the laminate properties. These features are suitable for the fabrication of composite structures where complex contours are required, performance and weight are critical parameters, and precision application of material in specific orientations is desired. Several complex aerospace parts such as wing skins, ducts, nacelles, and fuselage skins are fabricated using advanced fiber placement processes. Other DoD systems anticipate the use of these advanced materials and design concepts for munitions, armaments, and hull structures for manned and unmanned robotic vehicles.

The project is creating commercially viable production capabilities, and will share manufacturing enhancements with the commercial composite production community as appropriate. Recent accomplishments include: installation of the final state-of-the-art fiber placement machine (FPM) placing a total of three new FPMs into full scale production, the retrofit of a second FPM from a single headstock/tailstock configuration to a dual headstock/tailstock configuration, and the final installation of other ancillary production support equipment.

This project was funded through Congressional increase to the Title III budget. Total Title III funding is \$27.1M, augmented by \$15.3M of contractor cost-sharing. This was a sole source solicitation as only a single domestic source was identified for the specific technology of interest.

### **Light-Weight Ammunition Project (Map Location #20)**

The objective of this effort is to establish a domestic production capability for the manufacture of light-weight ammunition based on polymeric material. The initial focus is the development, production, and qualification of lightweight .50 caliber machine gun rounds that can be deployed in conventionally fielded weapon systems at a comparable cost to standard brass ammunition. The lightweight, polymer-cased .50 caliber ammunition weighs approximately 25% less than standard brass ammunition.

The contractor produced and shipped 5,000 rounds of its .50 caliber ammunition to support the qualification/basic safety testing at Naval Surface Warfare Center (NSWC) Crane, which was conducted from July - August 2014. The contractor's ammunition performed well in the vibration testing; no fractured cases were observed. Other test results are still being analyzed by the U.S. Marine Corps.

The contractor manufactured and delivered 1,200 .300 Winchester Magnum (WINMAG) rounds to the U.S. Army for testing and evaluation. The goal of this effort is to develop and

demonstrate accurate and reliable polymer-cased .300 WINMAG ammunition for use in sniper weapons, such as the XM2010 and the Modular Sniper Rifle (MSR).

A demonstration was held at Ft. Eustis, VA on 19 Sep 2014 whereby 1,000 rounds of the contractor's .50 caliber ammunition were shot from the three-barreled GAU-19 weapon system from a helicopter positioned on the ground. The main objective of the demo was to record and evaluate the vibration on the helicopter—to ensure the helicopter's structure was not deleteriously impacted. The contractor's ammunition performed well. A more extensive demo is now planned in CY2015/Q1 at Ft. Pickett, VA whereby 10,000 rounds will be fired from the GAU-19 from three different helicopters in flight.

This project was funded through Congressional increase to the Title III budget. The U.S. Marine Corps added \$3M. Total government funding on contract is \$15M, augmented by \$10K of contractor cost-sharing. An additional \$5M is pending contract award. This was a sole source solicitation as only a single domestic source was identified for the specific technology of interest.

#### **Lithium-Ion Battery Production for Military Applications (LIMA) Project (Map Location #17 )**

The purpose of this project is to establish a long-term, viable, world-class domestic manufacturer of high-energy density lithium-ion (Li-Ion) batteries that is responsive to customer requirements with respect to performance, reliability, quality, delivery, and price.

High energy density Li-Ion batteries are critical for a number of military systems, specifically for enhancing the endurance of Unmanned Aerial Vehicles (UAVs) and providing portable power to support the mission for the dismounted soldier (long endurance autonomous systems, tactical vehicles, unattended sensors, and reconnaissance and surveillance systems). The Li-Ion cells of interest will have an energy density greater than 250 Watt-hours per kilogram (Wh/kg) at 250 Watts per kilogram (W/kg) continuous (i.e. 1C rate) for military applications. The goal is to create a flexible manufacturing line capable of producing multiple battery form factors for both military and commercial applications. Another key goal will be to achieve a Manufacturing Readiness Level (MRL) 8: capable of supporting Low Rate Initial Production (LRIP).

The project will effectively reduce the cost of high energy density Li-Ion batteries by leveraging increased combined assembly line volumes, even at low production run volumes of individual battery form factors. There will be commensurate improvements in power density, discharge rate, temperature range and safety, and delivery of sample cells/batteries to the government for independent testing.

Three Phase I contracts were awarded in early 2013 and concluded in 2014. Phase I delivered sample cells for independent government testing along with strategic business and marketing plans. The Phase II option was a competitive down-select to one contractor with the basis for selection comprised of Phase I business plan deliverables, as well as technical and manufacturing accomplishments. The Phase II contract was awarded in September 2014 and is

focusing on refining Li-Ion ion cell chemistries for military applications, production facility and capacity expansion, process improvements and advancing to MRL 8.

The total project funding is \$31.9M, which includes Government funding of \$23.1M and Contractor Cost-share of \$8.8M. This was a competitive solicitation.

### **Lithium Ion Battery Production for Space (LISA) Project (Map Location #6)**

This Title III project supports the development of a domestic source for lithium-ion (Li-Ion) cells and their constituent active materials for spacecraft use. Li-Ion rechargeable battery technology provides higher power for longer durations with lower weight and favorable space constraints when compared to nickel cadmium (NiCd) or nickel hydrogen (NiH) rechargeable batteries. The Li-Ion battery offers the highest energy and power package of developed batteries today. Additional advantages include better recharging capability with no memory effect and increased temperature operating ranges. This technology offers designers a weight savings option compared to other battery types for overall weapon systems performance.

In 2013, the initial technical effort to create production capability for prismatic low earth orbit (LEO) cells and constituent materials was completed. In 2014, the effort shifted to the development of production capability for 18650-size wound cells for space launch vehicles and micro-satellites. This follow-on effort employs the long life material production capacity and the electrode production capability established in the earlier phase of this project, leveraging them with other industry partner proprietary technologies and a California Energy Commission grant to install 18650 cell assembly equipment. Thus far, the industry partner demonstrated proof-of-concept for a cell design that meets customer needs, improved its production facilities, and procured necessary manufacturing equipment.

This project was funded from the DoD Title III budget, plus other funding transferred from the Air Force and another government agency. A \$1M Congressional increase for Title III was provided during project execution. Total government funding is \$55.2M, augmented by \$15M of contractor cost-sharing. This was a competitive solicitation.

### **Low Cost Military GPS Receivers Project (Map Location #16)**

Military GPS receivers are vital equipment on the battlefield as they enable warfighters to perform strategic and tactical maneuvers with a high degree of confidence and success. Without secure, reliable GPS receivers, soldiers lack the necessary situational awareness and confidence when determining their specific position relative to fellow warfighters and enemy combatants. Military GPS receivers also contain anti-spoofing and anti-jamming technologies in comparison to commercially available, non-DoD lower-technology alternatives.

The primary objectives of this Title III project are to create domestic production capabilities for essential subcomponents for the Defense Advanced GPS Receiver (DAGR) and to pursue methods for reducing their weight, size, power-consumption and cost, while improving performance capabilities. A new phase was awarded in August 2013 to focus on improving size, weight, power consumption, cost, and capability, thereby continuing to evolve the capabilities of dismounted soldiers.

This project was funded through a Congressional increase to the Title III budget. Total government funding is \$11.1M, augmented by \$16.0M of contractor cost-sharing. This was a sole source solicitation as only a single domestic source was identified for the specific technology of interest.

### **Non-Aerospace Titanium for Armor and Structures Transformation Project (Map Location #33)**

The excellent strength-to-weight and corrosion-resistance properties of titanium make it useful for many structural applications. It also has excellent ballistics properties that, along with the low weight, make it ideal for armor. Due to large increases in commercial aerospace demand for titanium, lead times for titanium are approximately 6 months, while costs remain extremely volatile.

By working outside the aerospace titanium supply chain, this Title III project will help reduce cost and shorten delivery lead-times for structural titanium and titanium armor. The initial effort focuses on implementing the capability to direct-roll titanium and other alloy plate in widths and thicknesses for armor tiles on military ground vehicles. Military applications include armor, reactive armor tiles, and structural material for military vehicles, tanks, and naval ship piping, which is subject to corrosion.

Finishing equipment, installed in the first phase of the project, processed the following items: armor brackets, Joint Light Tactical Vehicle (JLTV) prototype parts, and components for retrofitted racking systems on DoD vehicles. The contractor procured and began installing a plate mill for enhanced in-house production capability.

This project was funded through a Congressional increase to the Title III budget. Total Title III funding is \$12.8M, augmented by \$2.1M of contractor cost-sharing. This was a competitive solicitation.

### **Polyhedral Oligomeric Silsesquioxanes (POSS™) Nanotechnology Project (Map Location #21)**

This Title III project is scaling up production of Polyhedral Oligomeric Silsesquioxanes (POSS®), a nano-sized material that, when used as a chemical additive, can greatly enhance the performance of polymers for a variety of DoD and commercial applications. POSS® has been demonstrated as useful in applications such as: radiation shielding and coatings for space-survivable microelectronics, coatings that prevent growth of tin whiskers on lead-free solder, aerospace air and fuel filters, food packaging, optical lenses, and weapon lubricants and cleaners. POSS® was the enabling catalyst for the world's first synthetic organ transplant in 2011 and is undergoing human clinical trials for organ regeneration and replacement.

During the course of this project, production capacity of POSS at the industry partner has grown from 50 tons to more than 500 tons annually. More than 250 POSS compounds have been created with 100+ synthesized and compounded for commercial use. The contractor achieved ISO 9000:2008 certification and a Manufacturing Readiness Level (MRL) of 9: Low Rate Initial

Production demonstrated, ready for Full Rate Production. However, demand has outpaced capacity for particular formulations, and Title III is currently involved in modernizing production controls and installing production equipment to meet requirements.

This project was funded through Congressional increase to the Title III budget. Total Title III funding was \$21.29 Million, augmented by \$2.22 Million of contractor cost-sharing. This was a competitive solicitation.

### **Radiation-Hardened Cryogenic Readout Integrated Circuits (Map Location #11)**

Title III resources are being utilized to establish a viable, domestic foundry for commercial production of less than or equal to 0.18 micron deep sub-micron CMOS Radiation-Hardened Cryogenic Readout Integrated Circuits (ROICs). These microelectronics are a critical technology employed in the manufacture of focal plane arrays (FPAs), which are utilized in high altitude and space-based imaging, and missile systems. The next generation imaging requirements are dependent on the availability of advanced ROICs that provide high density with analog components, smaller pixels (increased resolution), and increased functionality through on-chip processing. Additionally, ROICs must be physically larger (achieved through stitching technology) to meet increasing focal plane array size requirements, reducing particle counts to improve production yields, and speeding fabrication cycles. These improvements will collectively increase the mission capability of the systems.

Title III funding is providing industry the capability to produce less than or equal to 0.18um Large Format (LF) ROIC device per vendor design. Funding is also being used to determine radiation immunity standards via vendor surveys to better understand industry needs. Yields have increased 5-fold and continue to gain efficiency. Yield improvement has been attained through better failure analysis resulting in reduced defect densities. In addition, as part of the Title III effort, the contractor has attained Trusted Foundry certification.

This project was funded through a Congressional increase to the Title III budget. The Air Force added other funding to the effort. Total government funding is \$13.0M, augmented by \$19.7M of contractor cost-sharing. This was a competitive solicitation.

### **Read Out Integrated Circuit Foundry Improvement and Sustainability Project (Map Locations #1 & 10)**

A number of challenges are present related to the design and fabrication of Large Format (LF) Read-out Integrated Circuits (ROICs). As detector arrays grow in size and number of pixels per array (> 1 million), the complexity of the ROIC also increases and adds to the challenges of the foundry that must now utilize advanced CMOS processing techniques at 0.18 micron and below, with competitive wafer sizing (8 inches).

Other factors affect the design, processing, and performance of the ROICs for government space programs. The ROIC must exhibit very low noise to avoid contributing substantially to the noise of the sensor. Defect density in the ROIC reduces yield during manufacturing and may affect the operability of the sensor once it is hybridized. In addition to the low yields due to defect

density, wafer size, and design complexity, long periods of time between orders are common due to the relatively small market for LF ROICs, resulting in production gaps.

As a result, it is difficult in this environment to keep equipment and staff running at peak performance. The scope of the Title III ROIC Foundry Improvement and Sustainability Project is to maintain minimal, yet adequate, production capabilities at domestic foundries to ensure the necessary supply of strategic ROICs deemed useful for government space programs. The primary goal is a sustainment initiative where, in addition to running continuous production, there is the added objective of making continual design and process improvements so that more aggressive yields can be realized in a timely manner.

The first of two industry partners for this project was placed on contract in April 2010 and has increased their yields by five-fold in small wafer lots, demonstrating continued process improvement. Failure analysis has been improved with the capital purchase of an upgraded KLA Inspection Tool. This tool allows for closer inspection of 0.18 micron ROICs to detect smaller (and potentially damaging) defects that were undetectable with older inspection tools. The contractor continues to work closely with a design house to improve testing programs resulting in improved defect densities.

A second industry partner was placed on contract in June 2012. Utilizing 0.18 micron LF-ROIC chips, this contractor has produced remarkable power probe yields that have exceeded expectations. This supplier is also working closely with a design house to assist with required testing programs. This cooperation has led to faster yield reporting and identification of potential wafer defects.

The project was enabled with funding transferred to the Title III budget from the Air Force, Missile Defense Agency, and another government agency. Total government funding for the project is \$10.45M, or \$5.225M per industry partner. Cost-sharing/contributions by the contractors are \$5.66M and \$5.47M respectively. Competitive solicitations were the basis for execution of this project.

#### **Solid Rocket Motors Production Project (Map Location #4)**

This new Title III project will establish a state of the art production “digital factory” for the domestic production of solid rocket propulsion components utilized by the Missile Defense Agency’s Aegis Ballistic Missile Defense (BMD) system and other solid rocket motor programs. Of particular interest is the Standard Missile (SM)-3 Throttle-able Divert and Attitude Control System (TDACS) programs. This project will focus on modernizing the industry partner’s manufacturing processes by upgrading and replacing equipment and controls to enable a paperless, digitally based input and output manufacturing environment. This has the potential to appreciably reduce costs, significantly increase factory throughput and capacity, shorten cycle time, improve yield, and improve quality on the SM-3 TDACS programs and other solid rocket motor programs.

Contract award occurred September 2014. This Title III project will work in conjunction with FY15 efforts by the Missile Defense Agency. This effort will ensure that a critical domestic source remains economically viable and competitive after the conclusion of the Title III project.

Total Title III funding for this project is \$9.998M, augmented by contractor cost-sharing of \$10.205M. This was a competitive solicitation.

#### **Space Qualified Solar Cell Germanium Substrate Supply Chain Improvement Project (Map Location #14)**

The purpose of this project is to enhance and expand the ability of the domestic industrial base to produce space-qualified germanium substrates – a key enabler for space solar cells used to power government satellite systems. Commercial-grade germanium (Ge) substrates do not possess the quality necessary to produce high-reliability space solar cells. Ge substrates are the basis for the solar cells used on all National Security Space (NSS) satellites, and are forecast to continue as such for at least 10-15 years. Current state-of-practice solar cells built on Ge substrates operate at 28-30 percent efficiency. State-of-the-art Ge solar cells operating at 33 percent efficiency will transition to production in the near term, while 35-37 percent Ge solar cells are currently in development.

Major accomplishments in 2014 include introduction of the capability to reduce and melt germanium dioxide powder into 5-Nines pure (5N = 99.999%) germanium metal, then to zone-refine that metal to increase it to the 7-Nines pure (7N = 99.99999%) germanium metal. The 7N pure metal is used to grow germanium crystal boules which are sliced into substrates. Other accomplishments include increasing substrate production yields, developing a germanium fines capture and recycle system, and capturing business with a second strategic customer.

Total government funding for this project is \$8.55M, augmented by \$8.8M of contractor cost-sharing. Government funding is provided by members of the Space Industrial Base Council's Critical Technologies Working Group, under the terms of a MOA with the Title III office. This was a sole source solicitation, as a determination was made that only a single space-qualified domestic source existed.

#### **Thermal Battery Production Project (Map Location #23)**

The objective of this Title III initiative is to strengthen and expand the only domestic source for Cobalt Disulfide thermal batteries. Military unique, high performance batteries are the only viable power source for many strategic and tactical missile systems. The Missile Defense Agency and multiple DoD acquisition program offices identified high performance Cobalt Disulfide battery technologies as having insufficient domestic capacity and capability to meet program requirements. The focus of this Title III program is to scale up production capacity and expand capabilities required by military customers. The applicability of these batteries to a wide variety of DoD missile systems offers Army, Navy, and Air Force Program Offices the ability to greatly enhance system performance.

Major accomplishments in 2014 include the advancement of an internally developed cobalt disulfide material, and subsequent qualification and production for the Small Diameter Bomb Program. Several other major programs are in development with delta qualification activities underway.

This project was funded through Congressional increase to the Title III budget. Total Title III funding is \$19.6M, with no contractor cost-sharing. This was a competitive solicitation.



### **Traveling Wave Tube Amplifiers (TWTAs) for Space Project (Map Location #7)**

This Title III project builds on previous accomplishments by developing the infrastructure required to domestically produce advanced space-qualified K-band Traveling Wave Tube Amplifiers (TWTAs) designed for next generation commercial and government applications. A TWTAs is a vacuum electronic device whose function is to amplify a radio-frequency signal. K-band TWTAs provide superior signal strength and larger bandwidth compared to today's satellite communications.

Establishing a globally competitive domestic source for next-gen high power, space qualified, K-band TWTAs is necessary for the DoD to obtain high quality components, on time, and at a fair market price. This project will greatly reduce the schedule, performance, and cost risks to government satellite programs that are inherent in relying on one supplier. Recent accomplishments include: completed TWTAs designs, custom built automated test systems, and manufacturing high power K-Band TWTAs on a pilot production line.

Total government funding for this project phase is \$7.6M, augmented by \$7.6M of contractor cost-sharing. Government funding is provided by members of the Space Industrial Base Council's Critical Technologies Working Group, under the terms of a Memorandum of Agreement (MOA) with the Title III office. This is a follow-on effort to the Phase I sole source solicitation. This was a sole source solicitation as only a single domestic source was identified for the specific technology of interest.

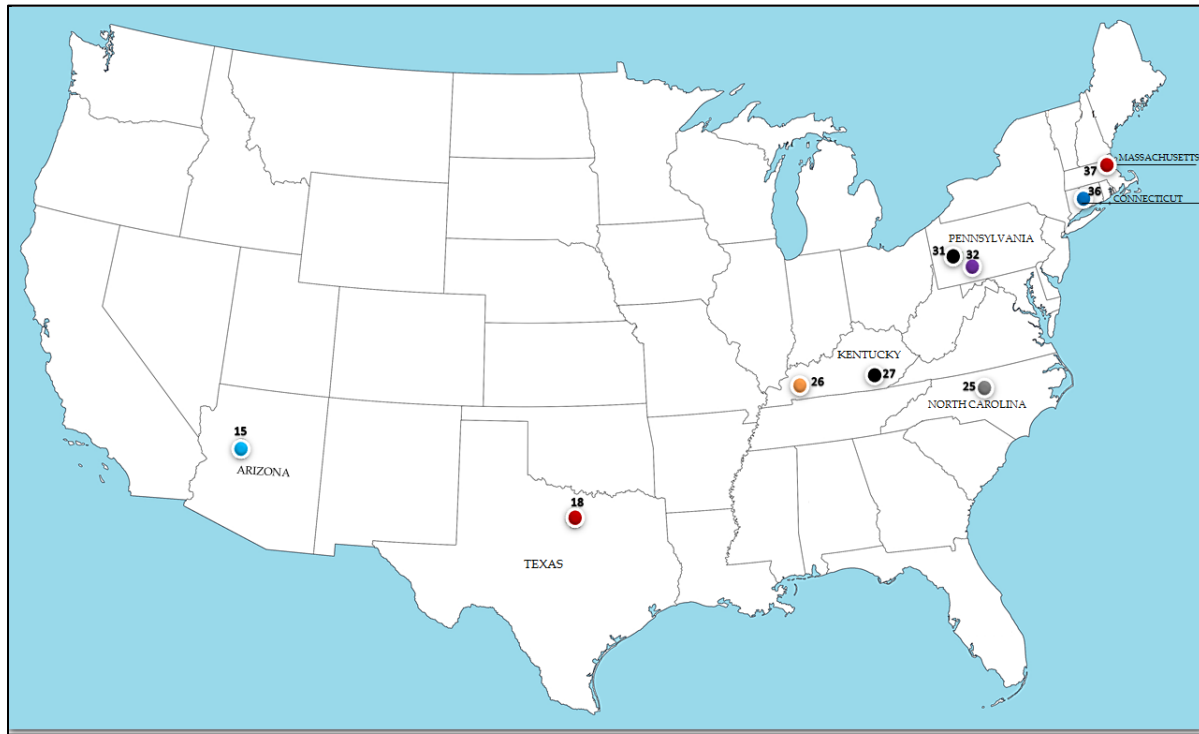
### **Tungsten Rhenium Wire Production Sustainment Project (Map Location #30)**

The objective of this Title III effort is to create a viable, domestic source capable of manufacturing a high yielding, reliable and reproducible tungsten-3% rhenium (W-3%Re) wire in a cost efficient manner. The quality of the material will be required to meet DoD and commercial microwave tube (MWT) industry standards for use in vacuum tube electronics.

Rhenium powder is mixed with tungsten powder to increase the re-crystallization temperature of the material, which makes the material more ductile, or able to be drawn into wire. Rhenium significantly reduces the brittle characteristics of tungsten at room temperature, and W-3%Re wire has much better ductility, stability, and tensile strength than pure tungsten in high temperature applications.

This project was competitive solicitation funded through a Congressional increase to the Title III budget. DPA Title III funding is \$4.86 augmented by \$1.12M of contractor cost-sharing.

## DPA Title III Projects - Concluded in 2014



### ALON<sup>®</sup> and Spinel Optical Ceramics Project (Concluded in 2014) (Map Location #37)

ALON<sup>®</sup> (aluminum oxynitride) and spinel (magnesium aluminate) optical ceramics are extremely durable materials with excellent mechanical and optical characteristics, sporting optical and mechanical properties similar to sapphire but producible in larger sizes, higher quantities, more complex geometries, and at lower costs. This is primarily due to the manufacturing processes, which utilize well-understood, conventional ceramic powder processing techniques.



#### Blackhawk ALON Wing Panel Armor



ALON<sup>®</sup> Transparent Armor represents the state of the art in ballistic windows, providing the highest level of protection at half the weight and thickness of conventional glass laminates. In addition, the transmission of ALON<sup>®</sup> Transparent Armor offers ~45% improvement in transmission for night vision goggles compared to conventional low lead glass products. ALON<sup>®</sup> Transparent Armor is currently being purchased for a number of military helicopters including the Blackhawk and Chinook helicopters for side panel armor protection for pilots.

#### Elbit Systems ALON Sensor Window

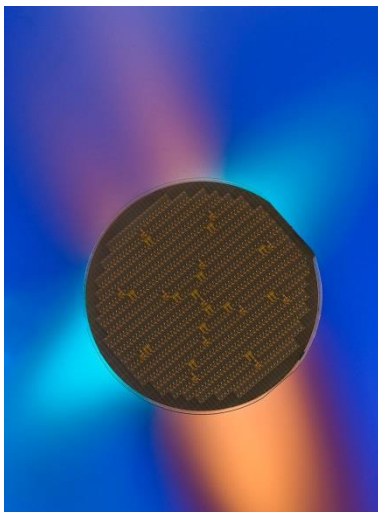
Future systems such as the Joint Air-to-Ground Missile (JAGM) and the Common Infrared Counter Measures (CIRCM) program require ultra-durable and affordable IR transparent dome materials. Both ALON and spinel are candidate materials for these applications. ALON has producibility advantages over spinel, while spinel transmits further into the IR than ALON, making it the material of choice for systems that require extended Mid Wave Infrared (MWIR) transmission. ALON<sup>®</sup> windows are also being used for sensor and laser systems on a number of military and commercial platforms which require ALON's combination of transparency and durability.

The multi-year Title III project concluded in 2014. Improvements gained under this project include the following:

- 70% improvement in powder utilization for small components (~6-in diameter)
- 40-50% increase in powder utilization for large plates (~15x27-in)
- 50% increase in the maximum size of ALON plates that can be produced in large quantities
- 300% increase in throughput for large ALON plates
- Ability to consistently produce large ALON blanks and windows suitable for reconnaissance applications
- 10x improvement in homogeneity
- 6x reduction in stress induced birefringence
- 700% increase in throughput for polishing ALON<sup>®</sup> Transparent Armor.

This project was initially funded through a Congressional increase to the Title III budget. Funding from the Air Force, Army, Navy, and the Industrial Base Innovation Fund (IBIF) added to the effort. Total Government funding is \$18.6M, combined with \$3.7M in cost-sharing by the contractor. This was a sole source solicitation as only a single domestic source was identified for the specific technology of interest.

#### **Gallium Nitride Radar and Electronic Warfare Monolithic Microwave Integrated Circuit Producibility Project (Concluded in 2014) (Map Locations #18 & 25)**



GaN Wafer

This Title III project partnered with two domestic companies to focus on increasing the yield, affordability, and availability of S-Band and Wideband monolithic microwave integrated circuits (MMICs) produced on 100 mm Gallium Nitride epitaxy on Silicon Carbide substrates. The primary objective was to achieve a Manufacturing Readiness Level (MRL) of 8, which indicates that production processes are ready to support Low Rate Initial Production (LRIP) of GaN MMICs.

This project focused on maturing GaN MMIC production processes to ensure domestic availability of these devices for next generation defense systems. MMIC technology offers the highest level of integration of active and passive components in the smallest form factor while GaN material enables higher power, efficiency and bandwidth, as compared to other existing semiconductor

materials. GaN Power Amplifier technology significantly enhances the Warfighters' capabilities by increasing radar ranges, sensitivity, and search capabilities compared to existing radar platforms based on other semiconductor technologies.

Upon conclusion of the project, the total yield for the improved Wideband and S-Band processes increased by greater than 110% respectively which translates to a better than 53% cost reduction for GaN MMICs. Additionally, the contractors improved the DC reliability of both processes. Throughout this project, more than 1.5 million device hours of reliability test data was collected. Early life failures seen in the initial MRA were virtually eliminated. Devices were re-engineered to extend the median lifetime predictions to greater than 600 million hours.

This project was funded in part with offsets transferred to the Title III budget from the Navy. Total government funding was \$35.4M, combined with \$3.6M in cost-sharing/contribution by one of the contractors. This project was awarded to two contractors through a competitive solicitation.

### **Military Lens System Fabrication and Assembly Project (Concluded in 2014) (Map Location # 31)**

This Title III project established a domestic resource for mono-spectral and advanced multi-spectral optical systems and lens components. This effort developed a manufacturing capability for design, fabrication, finishing, coating, assembly, and testing of mono- and multi-spectral night vision optical systems that can be integrated into military and commercial surveillance systems.

Multi-spectral systems are shared aperture systems that allow widely separated wavelength bands to be transmitted through a common aperture and share common elements in the optical train. They offer considerable advantages for the Warfighter, including weight and volume reduction, by allowing the Warfighter to carry fewer pieces of equipment; improving performance, by allowing both bands to utilize the full aperture of the systems; and optimized system design for a larger set of operating conditions/environments.

The industry partner installed advanced optical lens equipment in a dedicated new 30,000 square foot facility and initiated production. Equipment procurement and manufacturing improvements increased lens production capacity from less than 500 lenses to over 80,000 per year.

This project was funded through Congressional increase to the Title III budget. Industrial Base Innovation Fund (IBIF) also added funding of \$0.9M. Total government funding is \$8.8M, and is augmented by \$2.5M of contractor cost-sharing. This was a competitive solicitation.

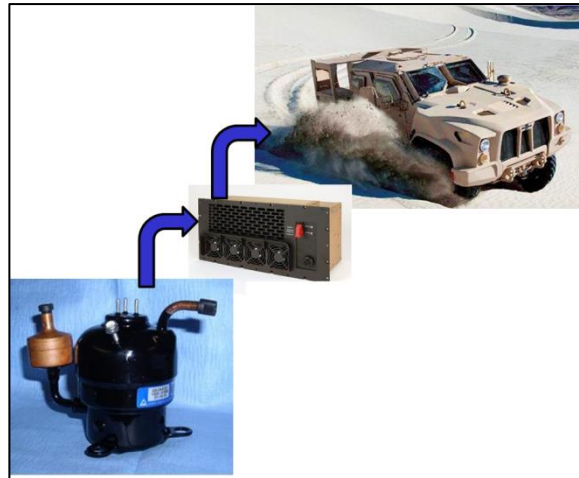


**Robotic High Volume Lens  
Generation, Polishing, and  
Assembly System; Optical Lens  
Handling Tray**

## **Mini-Refrigerant Compressors for Man-Portable Cooling Project (Concluded in 2014) (Map Location #27)**

Title III successfully collaborated with industry to establish a domestic, low-volume production facility for mini-refrigerant vapor compressors. The project's industry partner purchased a production facility in 2006, and Title III assisted with plant facilitation including the procurement of manufacturing, assembly, and test equipment. The project concluded in December 2014 after 9+ years of execution.

The mini-compressor weighs 1.3 pounds, has a diameter of 2.2", and a height of 2.7 inches. Contained within a hermetically sealed case, it features a sensor-less, brushless motor and operates on 12, 24, or 48 volt DC power. Industry is currently developing a capability for mini-compressors to operate on alternative input power options including solar power, and a universal power supply. Two models of the mini-compressor are available with slightly different displacement cooling capacities: a 360 W (1.4cc) and 455 W (1.9cc) product to meet different user requirements. In 2014, industry began producing quieter versions of these compressors to cater to commercial market requirements.



**Left to right: Mini-Compressor, ECU-Chill 550  
Electronics Cooling Unit, Joint Light Tactical  
Vehicle (JLTV)**

Although personnel cooling is a viable application (i.e. aircrew cooling and dismounted soldier cooling), this technology's primary DoD and commercial application remains with electronics cooling. The compactness of mini-compressors enables them to be installed within electronics cabinets to provide active cooling of components. This increases the performance, reliability, and life of mission-critical electronics systems in high temperature environments.

Today, miniature refrigeration compressors provide cooling to critical electronic components installed within Electronics Transit Cases for the U.S. warfighter. More than 1,500 MIL-hardened Electronics Transit Cases have been fielded to date in Mine Resistant Ambush Protected (MRAP) armored fighting vehicles operating in support of Overseas Contingency Operations. Mini-Compressors provide electronics cooling for Persistent Threat Detection Systems, which are fielded by the U.S. Navy. Mini-compressors may also be selected to provide electronics cooling for the Joint Light Tactical Vehicle (JLTV), which is currently in a competitive acquisition.

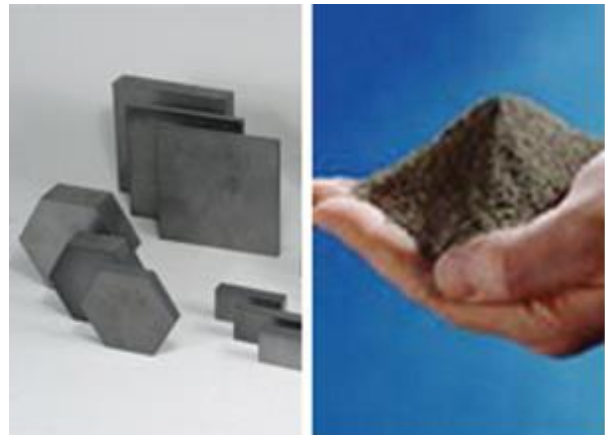
This project was funded through Congressional increase to the Title III budget. Total Title III funding is \$12.09M, augmented by \$0.6M of contractor cost-sharing. This was a competitive solicitation.



## **Silicon Carbide Powder Production and Ceramic Armor Manufacturing Project (Concluded in 2014) (Map Location #26)**

High-purity silicon carbide (SiC) powder, specifically “submicron alpha” SiC powder, is a critical material for national defense. This refined form of SiC powder is an essential ingredient for producing high-quality, light-weight, and cost-effective SiC ceramic armor for the U.S. warfighter. This project successfully modernized and expanded industry’s production capacity for submicron alpha SiC powder (a critical component of ceramic armor tiles currently under consideration for use on certain U.S. military vehicles), and created an industrial scale production capacity for SiC armor tile plates (of five different thicknesses) to meet national security needs.

This project focused on expanding the domestic manufacturing capacity of submicron alpha SiC powder, specifically the particulate size of 0.5 – 0.8 micron (500 – 800 nanometers). The project also established a new, viable domestic source for the production of SiC ceramic armor tiles. Industry presses 2”x2”, 4”x4”, and hexagonal (1.5”- 3”) tiles that are flat or three-dimensional in shape. The industry partner uses a pressure-less sintering method for producing its SiC ballistic tiles. These tiles compete with low cost steel plate armor for vehicles, as well as other ceramic armor materials (alumina and boron fiber). Thanks in large measure to this Title III project, SiC armor tiles achieved competitive standing with other armor material alternatives with respect to weight, performance, and product cost.



**SiC ceramic armor tiles & high-purity submicron alpha SiC powder**

The project accomplished two key technical objectives: 1) it successfully expanded the domestic supply of submicron alpha SiC powder by 180,000 kg per year (from 588,000 kg per yr. to 768,000 kg per yr.) to support SiC ceramic armor demand; and 2) the project expanded SiC ceramic armor manufacturing capacity to 157,000 tiles per year, and established a pilot level capability of manufacturing specialty, curved and hexagonal shaped tiles.

Military vehicular armor is the primary application for SiC powder and ceramic armor tiles. SiC ceramic armor is significantly less cumbersome than metallic alternatives, weighing 55% less on average than corresponding steel armor. SiC is also cost-competitive with ceramic alternatives (alumina and boron fiber) while offering ballistic performance comparable to other ceramics. SiC produces lighter armor, which can be applied high on a vehicle to lower its center of gravity, increase its maneuverability, and reduce rollover potential. Logistically, lighter armor reduces vehicle weight and thereby increases fuel range, improves maximum speeds, increases payloads, and reduces vehicular wear and tear.

The project also added milling, sizing and drying equipment for submicron alpha SiC powder. For ceramic armor tiles, the following production capabilities were established: binder

chemistry additions to alpha SiC powder, the application of hydraulic forming methods, de-binding and sintering, and finishing operations. The contractor implemented a plan for operational efficiency improvements, product enhancements, and quality improvements to meet user requirements. The industry partner conducted a thorough analysis of the SiC powder and ceramic armor marketplaces and implemented customer product qualification plans to meet objectives established in a comprehensive strategic business plan. A thorough marketing communications program was also established to pursue both government and commercial applications.

This project was funded through Congressional increase to the Title III budget. Total Title III funding is \$4.9M, augmented by \$6.2M of contractor cost-sharing. This was a competitive solicitation.

#### **Small Secure Satellite Communication Transceiver Project (Concluded in 2014) (Map Location #15)**

This Title III project established a domestic capability for the manufacture of small secure software-definable SATCOM Transceivers with the latest technology. A SATCOM Transceiver is a critical technology item that will be used to locate and recover U.S. DoD and Allied/Coalition Isolated Personnel in harm's way. The project introduced manufacturing technology, production processes and procedures, automated production systems, and achieved quality and affordability objectives.



The industry partner now has a product which has “sufficient features for demonstration,” and production is at Manufacturing Readiness Level 8: Pilot line

demonstrated, ready for Low Rate Initial Production (LRIP). All three modules (Digital Core, UHF RF, and L/S-Band RF) developed as part of the Title III project, are ready for LRIP. Manufacturing capacity is capable to meet current DoD requirements and is scalable for increased demand. Prototype transceivers, including line-of-sight and over-the-horizon, have been demonstrated, and the DoD is actively testing products that incorporate the new SATCOM technology. Ultimately, the project will provide greatly improved and more secure personnel recovery capabilities for the Warfighter.

The U.S. Army, Force XXI Battle Command, Brigade and Below Program Office provided Title III funding for this project. Total government funding was \$5.0M, with no contractor cost-sharing. This project was awarded via a competitive solicitation and concluded on schedule and on budget.

#### **Terahertz Spectrometer Project (Concluded in 2014) (Map Location #36)**

This project established a domestic, low volume capability for the manufacture of Terahertz (THz) Spectrometer chemical detection systems. These devices, which operate in the THz region, between the microwave and IR regions of the spectrum, will provide the DoD and

Department of Homeland Security (DHS) communities with an advanced solution for the detection of Toxic Industry Chemicals (TICs) in a gaseous environment.

The focus of the project, which leveraged prior work performed by the U.S. Army Research Laboratory (ARL), was to develop a lighter, smaller, more affordable spectrometer with automated detection software, a web interface for remote operation/monitoring, and an alarm capability. This evolutionary chemical detection system represented the contractor's fifth generation system.

At the conclusion of the project, the contractor assembled three next generation THz Spectrometer systems. Significant progress was made in reducing the size and weight of the system. Overall volume decreased by 63%, and weight was reduced by 55% as compared to the previous generation system. Also, an autonomous operation (operator-friendly) spectrometer was achieved. Previous systems required highly skilled engineers to operate them.



**Terahertz Spectrometer Chemical Detection System**

The THz Spectrometer has the ability to detect TICs within a highly cluttered environment (dust, dirt, etc.) and austere environment (high heat, high humidity). Other chemical detection systems may fail or give false alarms at a high rate. There is minimal upkeep and maintenance cost, as no expendables are required to operate these units.

This project was funded through Congressional increase to the Title III budget. Total Title III funding was \$3.6M, augmented by \$1.06M of contractor cost-sharing. This was a sole source solicitation as only a single domestic source was identified for the specific technology of interest.

### **Vacuum Induction Melting, Vacuum Arc Remelting Furnace Capacity Project (Concluded in 2014) (Map Location # 32)**

Low alloy, iron-based Vacuum Induction Melting, Vacuum Arc Remelting (VIM-VAR) steel is high purity, corrosion resistant steel that is processed through multiple melts under vacuum to reduce excess gases and other impurities. VIM-VAR steel is essential for many military applications including: jet engine bearings, engine mounts, helicopter rotor shafts and heads, and helicopter transmission gears and housings.

This Title III effort addressed production constraints and single points of failure to reduce unacceptably long lead times and ensure the domestic supply of low alloy, iron-based VIM-VAR steels for critical military components. At the height of Operation Iraqi Freedom and Operation Enduring Freedom, lead times for components produced using VIM-VAR steel rose from 13-20 weeks on average (pre-war) to more than 72 weeks. From 2004-2007, the U.S. Army investigated the supply chain for



**VIM Furnace**



several DoD systems and determined VIM-VAR steel production to be the source of the supply chain bottleneck.

This project achieved all the key performance parameters established and drastically reduced lead times for VIM-VAR steel, which have dropped precipitously from 72+ weeks to 14.8 weeks on average as of 2014. The industry partner's existing VIM furnace was refurbished, increasing melt capacity from 9.0M lb/year to 18.7M lb/year (as of 2014). Five additional VAR furnaces were added, boosting steel production by an additional 12.5M lb/year, and a 3200 ton open die forging press was rebuilt in 2010 to address the potential for catastrophic single-point failure by reinforcing the press's base and fixing a propagating crack therein.



These actions reduced unscheduled downtime for the press and increased its strength. The throughput improvement for an ultrasonic testing area, and the upgrade and expansion of an inspection lab supported new customer requirements and helped maintain the competitive lead times

#### **VAR Furnaces**

achieved on the project. Throughout the execution of this project, VIM-VAR order levels have grown in step with industry's expanded production capacity: order levels have increased from 750K lb/month (at the outset of the project in 2008) to 1.6M lb/month (in 2014).

This project was funded through Congressional increase to the Title III budget. Total Title III funding was \$25.6M, augmented by \$33.5M of contractor cost-sharing. This was a competitive solicitation.

### **DPA Title III Projects - Pre-Award / Active Acquisition in 2014**

#### **Activated Carbon Capacity Expansion Project**

This potential Title III project will advance the domestic production of activated carbon, specifically military-grade material used as filtering medium against chemical, biological, radiological, and nuclear (CBRN) toxic threats. The effort will focus on utilization and improvements of industrial manufacturing capabilities and quality management systems to meet DoD activated carbon performance requirements.

The United States is reliant on a single manufacturing facility for military-grade activated carbon to support CBRN protection requirements for all federal, state and local agencies. This facility is operating at 100% capacity, and no alternative source exists. This project will expand production capacity at the current facility and establish a second, sister production operation at a geographically separate location to ensure adequate capacity is available to meet current and future national defense and homeland security requirements.

The DPA Title III Program Office has programmed \$26.135M from previously appropriated funds for this initiative and \$13.856M across the FY15-17 DPA Title III budget for this initiative – a total of \$39.991M. The Joint Program Executive Office (Chem/Bio) pledged to

transfer \$10M to Title III for the effort. This is a competitive solicitation, and contract award is anticipated in calendar year 2016.

### **3D Microelectronics for Information Protection Project**

Many of the DoD's most sophisticated weapon systems and communications systems, by their very nature, are operated in close proximity to enemy combatants. UAVs and other weapon systems operating in contested areas unintentionally fall into our adversary's hands. Once these systems are in enemy hands, state-of-the-art reverse engineering equipment and techniques are used to create effective countermeasures to U.S. systems. Adversaries are able to copy and create enhancements over original systems, and may attempt to subvert the trusted supply chain for U.S. systems.

Miniaturization and densification of microelectronics are examples of technical strategies that can be deployed on several critical defense platforms to increase resiliency and increase technology protection of weapon systems. Recent innovations, enabled by integrated High Density (HD) packaging technology, which accepts a wide range of custom and Commercial off the Shelf (COTS) components, will drastically increase security of the DoD's most critical platforms. These advancements will also increase the opportunity for foreign military sales, thus reducing the production costs for the U.S. government, and strengthening the viability of the domestic defense industrial base.

This potential project was funded in part through Congressional increase to the Title III budget. Total government funding for this project is \$13.2M. This is expected to be a competitive solicitation, and contract award is anticipated in calendar year 2016.

### **Cadmium Zinc Telluride Production Project**

The purpose of this potential project is to enhance the ability of the domestic industrial base to produce large format, space-qualified cadmium zinc telluride (CZT) substrates for use in government satellite systems. Due to evolving National Security Space (NSS) threat requirements, several agencies responsible for missile early warning, missile defense, and other space requirements need to maintain a strong industrial base for mercury cadmium telluride (MCT) based infrared detector technology. A key material for the MCT detector arrays is the lattice-matching substrate CZT on which the detector array is grown. Existing domestically-produced CZT substrates do not meet the size and quality requirements necessary to produce large, space-quality infrared focal plane arrays.

This effort will focus on expanding CZT boule growth and large format, (211)-oriented substrate production; the stretch objective is the production of 9cm x 9.5cm substrates from 150mm diameter boules. Total government funding for this project is \$9.88M, provided by members of the Space Industrial Base Council's Critical Technologies Working Group, under the terms of a MOA with the Title III office. Contractor cost-sharing is anticipated. This is a competitive solicitation, with the contract award anticipated in calendar year 2015.

## **Green Energetics Project**

This potential Title III project will expand the domestic production capacity of copper(I) 5-nitrotetrazolate (DBX-1) to meet DoD qualification and production requirements and support an anticipated, emerging commercial market. DoD applications include, but are not limited to; aircraft pyrotechnic transfer lines, cartridge actuated devices (CADs), propellant actuated devices (PADs), anti-personnel obstacle breaching systems (APOBS), and munitions.

DBX-1 is an alternative explosive powder which incorporates no toxic or environmentally undesirable elements. Primary explosives are essential to the national defense; however, many are no longer desirable as they contain regulated toxins that present pernicious environmental, health and safety concerns. This effort will scale-up DBX-1 domestic production capabilities to a minimum 1 kg batch size to replace existing toxic primary explosives: lead azide (LA) lead styphnate (LS), and, mercury (II) 5-nitrotetrazole (DXN-1).

This project was funded through Congressional increase to the Title III budget. DPA Title III funding is \$3.52M. Contractor cost-sharing is anticipated.

## **Next-Generation Star Trackers System Project**

This potential project will establish the development and production of an affordable and reliable modular, Next Generation Star Tracker System (NGSTS) that uses advanced domestically-produced CMOS detectors with a capability that meets the specifications of the DPA Title III Advanced CMOS Capability Project. This involves adherence to the Staring Technology for Enhanced Linear Line-of-site Angular Recognition (STELLAR) specification. A NGSTS with CMOS technology is needed to meet military and civil U.S. Government (including National Security Space) and commercial market demands for the foreseeable future, and will reassert the viability and competitiveness of the domestic industrial base.

The U.S. Government (USG) considers a modular NGSTS to be capable of meeting a range of specifications (i.e., environments, sensitivities, update rates, etc.), for a range of space-borne Medium-Accuracy Star Trackers (MAST: 1-20 arcsec), with the potential to also meet High-Accuracy Star Trackers (HAST: <1 arcsec) specifications, for both commercial and USG space applications, all from a single basic system design. A MAST designed to target a majority of the global technical requirements with a common architecture and/or footprint, is considered to be the baseline for the modular NGSTS design. Customization of electronics, software, optics, detectors, structures, etc. from baseline design will be required to meet specific program requirements.

This project was funded through Congressional increase to the Title III budget. DPA Title III funding is \$19.6M. Contractor cost-sharing is anticipated. This is a competitive solicitation, and contract award is anticipated in CY2016.

## **Silicon Carbide Fiber Production of Ceramic Matrix Composites Project**

This potential Title III project will establish the domestic production of silicon carbide fiber, specifically high temperature fibers used in ceramic matrix composites. SiC fiber is a building block of ceramic matrix composites (CMCs) which are used in applications where high temperature resiliency and durability are paramount. SiC-fiber-based CMCs have proven themselves to be a material of choice in designing the military aircraft turbine engines of the future. Research and development work has shown that the use of SiC CMCs can improve aircraft jet engine fuel efficiency by as much as 25%, extend flying ranges by 25 to 30%, and increase thrust 5 to 10% when compared with current technology. A sustainable domestic SiC fiber production capability is an essential element in achieving these performance improvements for national security applications in addition to applications in commercial aircraft turbine engines, industrial gas turbines, and nuclear fuel rod cladding.

Silicon carbide fiber is commercially manufactured by two companies, both in Japan, neither of which has demonstrated a willingness to increase capacity. U.S. domestic companies are actively researching SiC fiber manufacturing processes. The high cost of SiC fibers from Japan limit product insertions to only CMC components which can justify the premium cost of this enabling material. Current limited demand for SiC fiber from both DoD and commercial markets presents high risk to industry and has served as a barrier to investment of corporate resources to install the necessary additional manufacturing capacity to meet future demand. The effort will focus on establishment of industrial manufacturing capabilities for affordable production to meet DoD demand.

This potential project was funded through Congressional increase to the Title III budget. DPA Title III funding is \$22.0M. Contractor cost-sharing is anticipated. This is a competitive solicitation, and contract award is anticipated in calendar year 2015.

## **Steel Plate Production Project**

The goal of this potential Title III project will be to enhance existing domestic capabilities to produce very wide (at least 150 inches), very thick (up to and including 8 inches) and very heavy (up to 75 tons) Navy-grade alloy steel plate, specifically alloys HSLA-65, -80, -100, -115 and HY-80 & -100. The demand for specialized steel plate of the required thicknesses, widths and specifications for Navy applications is cyclical and without a widespread commercial application. Consequently, there is an insufficient return on investment (ROI) for the domestic industry to invest in production enhancements that can reduce variation in thickness and flatness, and improve surface finish and support increased throughput.

Potential benefits to the Navy as a result of upgrading outdated steel production facilities, tooling, and processes include reduced overhead costs related with the manufacturer's maintenance of aging resources, and lower costs associated with a reduction in non-value added re-work for shipbuilders.

Total government funding for this project is \$17.6M, provided by a Congressional increase to the Title III budget combined with funding provided by the U.S. Navy under the terms

of a MOA with the Title III office. Contractor cost-share is anticipated. This is a competitive solicitation, and contract award is anticipated in mid-calendar year 2015.

### **Submarine Valve Regulated Lead Acid Batteries Project**

This potential Title III project will advance the domestic production of valve regulated lead acid (VRLA) batteries used in submarines. The effort will focus on utilization and improvements of industrial manufacturing capabilities and quality management systems for affordable production to meet DoD submarine VRLA battery performance requirements. This includes an increased battery life expectancy with minimal submarine VRLA battery intervention (cell replacements, isolations, and/or charge-profile adjustments). This is critical, given the varied scenarios encountered in U.S. Navy submarine operating environments.

This project was funded through Congressional increase to the Title III budget. DPA Title III funding is \$19.36M. Contractor cost-sharing is anticipated. This is a competitive solicitation, and contract award is anticipated in late calendar year 2015.

## **C.2 DoD ManTech Component Program Summaries**

### **C.2.1 Army Manufacturing Technology Program**

The Army Manufacturing Technology Program's mission is to provide affordable and timely manufacturing solutions addressing the Army's highest priority needs. ManTech exists to improve end-item affordability by addressing manufacturing and producibility risks, thereby enabling the transition of critical technologies to weapon system platforms. The program accomplishes this by linking Army program offices, the Army Science and Technology (S&T) community and the defense industrial base to demonstrate effective, efficient, affordable and adaptable manufacturing processes that are typically beyond the risk of these groups to address on their own.

The Deputy Assistant Secretary of the Army for Research and Technology (DASA(R&T)) is responsible for the Army ManTech Program. The DASA(R&T) provides strategic guidance and is the final approval authority for Army ManTech Projects. The U.S. Army Research, Development and Engineering Command (RDECOM), a subordinate command of the Army Materiel Command (AMC), has been designated as the Army's ManTech Program Manager. Projects within the ManTech portfolio are executed by the Army S&T community in close coordination with relevant Program Executive Office/Program Manager (PEO/PM) transition partners. These project offices within the community are responsible for coordinating capability goals, deliverables, projected cost/benefit data and conducting transition and implementation planning for the execution of individual ManTech projects. This allows the Army to maximize technology transition by leveraging both technical and acquisition subject matter expertise for specific weapon systems. This also results in a balanced portfolio aligned with S&T, Program Executive and Management Offices and Department of the Army priorities.

## Investment Strategy

The investment strategy for the Army ManTech Program is to address requirements relevant to the Program stakeholders. These stakeholders consist of primary transition partners and include the Army PEOs, PMs, the Army S&T community, and industry. The ManTech office engages these groups to identify priority efforts for the program to address.

Current Investments are aligned to the following Army S&T portfolios:

- *Air Portfolio* – improves manufacturing processes to include improved power-to-weight ratio, specific fuel consumption, and affordable manufacturing of lighter-weight, multi-functional coatings for wear resistance
- *Ground Maneuver Portfolio*- automates armor manufacturing, affordable vehicle protection and transparent armor
- *Lethality Portfolio* - addresses manufacturing cost and risks associated with energetic materials and component subsystems of missiles and munitions, cannon barrels and offensive weapon delivery systems
- *Innovative Enablers Portfolio*- utilizes digital product data, reverse engineering, and robust supply chain tools to reduce acquisition lead times and system life cycle costs
- *Soldier/Squad Portfolio* – provides affordable manufacturing of lighter-weight, multi-functional materials, and power systems that directly benefit the Soldier
- *Command, Control, Communications and Intelligence Portfolio*- addresses the manufacturing improvements for positional, navigational and timing devices (e.g. Global Positioning Systems), situational awareness displays, and electro-optics systems

ManTech proposals are vetted and prioritized through a series of stakeholder reviews and criteria-based evaluations. Evaluation criteria are centered on alignment with the stakeholder-identified investment areas, the strength of the projected transition, the projected impact on end-item or system affordability and the overall benefit to the Army. Upon funding a project, the ManTech office tracks cost, schedule, performance and transition/implementation planning activities through semi-annual Internal Program Reviews (IPRs). These IPRs and other supporting program documentation inform future strategic planning and feed directly into the Army ManTech budget item justifications and success stories.

## Highlighted Projects

One of the highest priorities for the Army is lightening the Soldier's load. An example of Army ManTech's strategy in support of this priority is enabling hybridized manufacturing processes for lightweight body armor. Direct coordination with PM SPIE (Project Manager - Soldier Protection and Individual Equipment) and the industrial base has effectively implemented these manufacturing improvements through a new specification for improved body armor. This project was recognized with the 2013 DoD ManTech Achievement Award.

IMX-104 (Insensitive Munitions eXplosives formulation number 104) is a newly developed insensitive munitions (IM) explosive formulation used in munitions such as the 81mm High Explosive (HE) Mortar. The manufacturing technology was demonstrated at Holston Army Ammunition Plant (HSAAP) and transitioned to full production.

Army ManTech investments in transparent spinel armor increased production capacity for large transparent ceramic-based armor plates by addressing base material processing, scale up tooling sizes for larger batch processing, improvements to secondary processes such as grinding and polishing, and development of new non-destructive evaluation processes for inspection. Based on Army ManTech investments and achievements, the Navy is now investing in even larger sized windows for use on their ships.

Additional details on these efforts can be found at [www.armymantech.com](http://www.armymantech.com).

### **C.2.2 Navy Manufacturing Technology Program**

The Navy ManTech Program provides for the development of enabling manufacturing technology and the transition of this technology for the production and sustainment of Navy weapon systems. Customers range from the acquisition program managers (PMs) and industry responsible for transitioning major Navy weapon systems from development into production, to the logistics managers at the naval depots and shipyards responsible for repair, overhaul, and remanufacture of major weapon systems.



The Navy ManTech Program is managed by the Office of Technology within the Office of Naval Research (ONR), with direct oversight from the Chief of Naval Research. ONR's Office of Technology is composed of transition-centric programs including ManTech, Future Naval Capabilities (FNCs), Small Business Innovation Research (SBIR) / Small Business Technology Transfer (STTR), and other transition initiatives.

The Navy ManTech Program executes through its Centers of Excellence (COEs) with expertise in specific technology areas. ManTech's seven COEs are: Composites Manufacturing Technology Center (CMTC) (Anderson, SC); the Electro-Optics Center (EOC) (Freeport, PA); Electronics Manufacturing Productivity Facility (EMPF) (Philadelphia, PA); Energetics Manufacturing Technology Center (EMTC) (Indian Head, MD); Institute for Manufacturing and Sustainment Technologies (iMAST) (State College, PA); Navy Metalworking Center (NMC) (Johnstown, PA); and the Naval Shipbuilding and Advanced Manufacturing Center (NSAM) (Summerville, SC).

#### **Service Focus**

Reducing the acquisition cost of current and future platforms is a critical goal of the Navy. As a result, ManTech adopted an affordability investment strategy in 2006 and is currently focused on affordability improvements for major acquisition platforms including: CVN 78 Class

Carrier, DDG-51 Class Destroyer, VIRGINIA Class Submarine (VCS) / OHIO Replacement Program (ORP), the Joint Strike Fighter (JSF), and, recently added for FY16, the CH-53K Heavy Lift Helicopter. Navy ManTech aids these key programs in achieving their respective affordability goals by transitioning needed manufacturing technology which, when implemented, results in a cost reduction or cost avoidance (measured as a per-hull or per-aircraft cost reduction).

### Program Initiatives

Although different in focus, scope, and size, ManTech's affordability initiatives function similarly. For each, ManTech has established an IPT with representatives from Navy ManTech, the platform program office, and representative industry. The IPT meets regularly to coordinate and review the portfolio and ensure that projects are completed in time to meet the platform's window of opportunity for implementation.

Taking the VCS initiative as an example, extensive interaction and cooperation between Navy ManTech, the COEs, General Dynamics Electric Boat, Huntington Ingalls Industries – Newport News Shipbuilding, PEO (Subs), and the PMS 450 Program Office has resulted in a focused ManTech initiative that continues to successfully transition manufacturing technology resulting in affordability improvements for VCS.

### Investment Profile

Funding for the Navy ManTech Program is approximately \$50-55 Million per year within the FY14-FY19 timeframe. Funding has remained relatively stable for the past ten years and is expected to continue at approximately that level. Strategic planning is an ongoing effort. Navy ManTech annually analyzes acquisition scenarios/plans to determine major ship and aircraft acquisition programs that might benefit from a close partnership with Navy ManTech. Platforms for investment are determined by total acquisition funding, stage in acquisition cycle, platform cost reduction goals, and cost reduction potential for manufacturing.

### Summary

With affordability as its focus, Navy ManTech is committed to working with acquisition programs and industry to provide the technology needed to reduce production costs. The continued collaboration of ManTech, program offices, and industry on cost-reduction opportunities can and will help platforms achieve their affordability goals.

## C.2.3 Air Force Manufacturing Technology Program

### Overview

Air Force ManTech develops, demonstrates, and transitions advanced manufacturing processes and technologies to reduce costs, improve quality/capability, and shorten cycle times of weapon





systems during design, development, production, and sustainment. The program's major tenets are: improvement of manufacturing processes and technologies; collaboration with government acquisition program offices, industry, and academia; investments in technologies that can be applied to different applications and systems that are beyond a reasonable risk level for industry alone; and customer commitment for implementation. ManTech objectives are achieved through partnerships at all industry levels, from large prime contractors to small material and parts vendors.

## Air Force ManTech Vision

AF ManTech's vision of "attaining next-generation agile manufacturing" reflects a studied review of stakeholder needs and Air Force priorities, coupled with a growing national consensus that an aggressive and transformative manufacturing approach is necessary to meet critical Air Force capabilities. The vision has four strategic thrusts: (1) Moving Manufacturing Left, (2) a Cradle-to-Cradle Digital Thread, (3) a Responsive, Integrated Supply Base, and (4) Factory of the Future. More specifically, these thrusts call for: a greater up-front awareness of manufacturing readiness issues and opportunities; highly innovative approaches to overcoming defense-unique production challenges during the research, design, production, and sustainment of a system, seamlessly supported by digital information; the ability to rapidly and affordably produce smaller lots of more specialized systems across global supply networks; as well as advanced physical manufacturing operations that intelligently manage environmental footprints and long term impacts.

## Service Focus

Air Force ManTech's near-term efforts include affordability and producibility improvements for advanced turbine engines, stealth, depot efficiencies, space solar cells, and advanced radar. Air Force ManTech is also pursuing a long-term strategy for more affordable systems based on helping achieve a new level of efficiency and agility in the U.S. industrial base. Priorities are set based on higher headquarters strategic guidance (e.g. AF Strategic Plan, AF S&T Strategy), assessments of acquisition and AFRL program requirements, and insight into industry opportunities (such as IR&D).

## Successes

AF ManTech has a long history of boosting Air Force capabilities. These investments have reduced acquisition costs by billions of dollars. For example, the 1980s project Retirement for Cause successfully implemented life extension technologies for turbine engines and saved over \$500 Million within 10 years and continues to lower costs today. A few recent examples of success in producibility, affordability, and capability are provided below.

- Air Force ManTech Manufacturing Readiness Assessments helps programs identify and reduce risk of developing next generation turbine engines.
- Thin Walled Recuperator using Additive Manufacturing: Propulsion system components are limited in their design and the materials with current manufacturing methods.

## Initiatives

- The Advanced Technology for Engine Manufacturing (ATEM) effort will enable performance improvements through advancing the producibility of advanced structures and assemblies.
- Complex of the Future - AFSC has embarked on an effort to define a 30 year vision of what the Air Force complexes should look like.

## Investment Profile

The Air Force's investments support activities across all Air Force product lines including: Aeronautical; Armament, Directed Energy Systems, Command & Control, Intelligence, Surveillance & Reconnaissance (C2ISR) Electronics, and Space Systems.

## Summary

The Air Force Manufacturing Technology Program is a warfighting capability and system affordability multiplier. Serving as the AF enterprise program to work strategic issues and opportunities in manufacturing readiness, it has a proven record of boosting performance and cutting cost and schedule in acquisition and sustainment. AF ManTech will continue to pursue high-return opportunities across the acquisition and sustainment spectrum.

### **C.2.4 Defense Logistics Agency (DLA) R&D ManTech Program:**

#### Overview

The Defense Logistics Agency (DLA) Office of Research and Development (R&D) develops innovative capabilities and processes that improve Agency operations and strengthen the industrial base for both peacetime and wartime. R&D provides DLA leadership with a mechanism to develop, implement, and evaluate prototype concepts and new technologies that will help the Agency meet its strategic goals. By design, the program mitigates risk by developing and testing advanced business practices, manufacturing processes, techniques and equipment on a small scale before major investments are made. R&D is charged with conducting research and development in all areas relevant to the DLA mission that support logistics, manufacturing, or the broader DOD manufacturing and industrial preparedness efforts.

#### Agency Focus

The Defense Logistics Agency is America's combat logistics support agency. Our mission is to provide effective and efficient global solutions to warfighters and our other valued customers. DLA supplies the nation's military services and several civilian agencies with the critical resources they need to accomplish their worldwide missions. When our Soldiers, Marines, Sailors and Airmen are supplied, fueled, nourished, moved, or healed, DLA plays a vital role. DLA also provides wide-ranging logistical support for peacetime and wartime operations, as well as emergency preparedness and humanitarian missions.

The DLA Director recently released DLA's Strategic Plan, which highlights DLA's continued priorities and identifies five goal areas that represent the foundational catalysts we believe are necessary and relevant to realize our vision: 1) Warfighter First, 2) People and Culture, 3) Strategic Engagement, 4) Financial Stewardship, and 5) Process Excellence. A key mandate in the DLA Strategic Plan is to "leverage DLA's Research and Development (R&D) program to infuse innovation into our solutions" to achieve DLA's Goal #1 "Warfighter First."

#### Initiatives

DLA R&D ManTech achievements and initiatives share a common objective - to support the Warfighter by delivering materiel solutions offering measurable operational improvement. Some of DLA R&D's accomplishments are described below that reduce costs, increase quality and readiness, and improve processes throughout the supply chain. Examples include:

- Lithium Carbon Monofluoride (Li-CFx) Soldier Batteries: Establish the manufacturing capability for high energy hybrid Li-CFx military batteries to reduce soldier-carried weight, improve battery performance, and reduce logistics costs.
- Dielectrically-Isolated Transistor-to-Transistor Logic (TTL) Microcircuits: Develop a manufacturing capability for Dielectrically Isolated TTL Microcircuits to DLA's existing Microcircuit Emulation capabilities, which reduces redesign costs and increased readiness by providing microcircuit spare parts critical to hundreds of weapon systems.
- 3-D Printed Casting Cores for Engine Airfoils: Optimize Ceramic Stereolithography process to manufacture casting cores for engine airfoils.
- Packaging of Meals Ready to Eat (MRE): Develop modeling software for the manufacturers to use in packing and packaging of primary MRE packages, boxes and palletized shipping containers to minimize entrapped air and eliminate redundant packaging materials.
- Additive Manufacturing Parts Demonstration with U.S. Navy Air Systems Command (NAVAIR): This DLA/NAVAIR collaborative partnership sought to demonstrate the development of an Additive Manufacturing (AM) Technical Data Package and the actual manufacturing using AM for sourcing two polymer parts of mutual interest.

#### Summary

DLA's R&D programs are designed to deliver responsive, innovative solutions that assist DOD readiness, support current strategies and operations, and anticipate future logistics and manufacturing needs while aiming to reduce cost and risk. DLA ManTech continues to refine its ability to respond quickly and effectively to the needs of the military. With a history of progress in manufacturing technologies and processes, DLA ManTech's future will see continued success in acquisition best practices and manufacturing process development.

#### **C.2.5 The OSD Defense-wide Manufacturing Science and Technology (DMS&T) Program**

The Defense-wide Manufacturing Science and Technology (DMS&T) Program was established in response to a recommendation from a landmark 2006 DSB ManTech study. The DMS&T core program develops manufacturing processes for emerging technologies and transitions advanced manufacturing processes and technologies for achieving significant productivity and efficiency gains in the defense manufacturing base. The program addresses cross-cutting, game changing initiatives that are beyond the scope of any one Service or Agency. It complements the other Component ManTech programs by focusing on early, emerging technologies, cross-cutting DoD priorities, and enterprise-wide above the factory floor manufacturing issues. DMS&T initiatives are identified and ranked through road mapping activities, RFIs, Workshops, BAAs, Alignment to defined Capability Gaps and Data Call activities with JDMTP representatives and are intended to benefit multiple defense systems and platforms. Planning activities are conducted in collaboration with DoD and industry manufacturing representatives and are intended to benefit multiple defense systems and platforms. Current technology thrusts include Advanced Electronics and Optics, Advanced Materials and Manufacturing and Enterprise & Emerging Processes. Pervasive investments have served as incubators for the development of Manufacturing Innovation Institutes.

Another major element of the DMS&T Program consists of Manufacturing Innovation Institutes (MIIs): MIIs are DoD leadership-directed public –private enterprises (with at least a 1:1 cost-share) focused on advancing manufacturing R&D throughout the U.S. Industrial base. The industry led partnership with government leverages regional and public-private partnerships to spur innovation and competitiveness of U.S. manufacturing. DoD MIIs are 5 year cooperative agreements executed by the Air Force, Navy and Army. Entry requirements for all DoD Institutes is a MRL 4-7. Institutes must become self-sufficient after five years of federal core funding. Current DoD MIIs consist of:

- America Makes (AF Lead): Additive Manufacturing
- DMDI (Army Lead); Digital Manufacturing & Design
- LIFT (Navy Lead): Light Weight Innovations for Tomorrow

### **DMS&T Core Portfolio**

The current portfolio consists of three primary investment areas; Advanced Materials and Manufacturing, Advanced Electronics and Optics and Enterprise and Emerging Processes. In addition OSD has developed four new initiatives aligned to our primary investment bins, Advanced Propulsion, Transparent Ceramics, Radar Affordability & Electronic Warfare and Cyber Security.

#### **Primary Investment Area Summaries:**

- Advanced Materials & Manufacturing: Funded efforts address manufacturing technologies for a wide range of materials such as composites (OMCs, CMCs, and MMCs), metals, monolithic ceramics and nano-materials. Through efficiency gains these manufacturing technologies will accelerate delivery of new capabilities (COIs, LLRDPs, QDR, etc.). In addition advanced manufacturing concepts will impact current and future operational shortfalls.

- Advanced Electronics and Optics Funded efforts address manufacturing technologies for a wide range of applications, sensors, power generation, switches, optics and sensors to see/sense through walls/obstructions/foilage. Technologies address S&T capability gaps (COIs, LLRDPs, etc.) and operational shortfalls within the defense manufacturing industrial base including warfighter deficiencies.
- Enterprise and Emerging Processes, developing manufacturing solutions (tools) using newly developed interoperable protocols. Engage and stimulate a broad base of software and system architects to develop advanced enterprise, facilities and control applications. Primary impact is workforce development focused on both the creation of manufacturing intelligence and enhanced manufacturing capabilities. S&T Focus: Advanced Manufacturing & Large Data Analysis / Modelling & Simulation.

## **Summary**

The DMS&T Program satisfies an essential need within the DoD manufacturing enterprise by attacking cross cutting, multi-service manufacturing gaps and developing material Processing and Fabrication solutions in parallel with associated technology development efforts. The program has substantially improved affordability, cycle time, and performance. DMS&T represents the sole OSD-directed manufacturing technology program, and it continues to build an investment portfolio delivering game-changing capabilities within the defense manufacturing enterprise.